Final Report:
Inventory of Invasive Exotic Plants of Colonial National Historical Park

December 20, 2000

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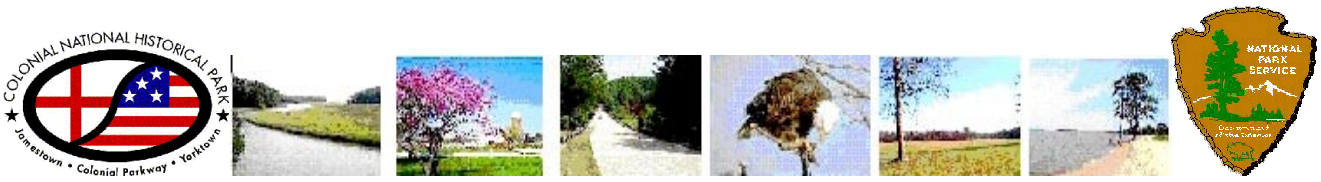

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Executive Summary

Invasive exotic flora is considered a major threat to the natural integrity, and agricultural and economic well being of the USA and nations worldwide. It is now a major initiative of Federal land management agencies and the object of a Presidential Executive Order to begin control of invasive exotic species.

To address these concerns, Colonial National Historical Park initiated in April 1999 a two-year inventory of invasive flora. This project was funded through the NPS NER regional science funds. The purpose of this study was to identify and map invasive flora within park boundaries and prioritize them for management. A protocol was developed that required walking a series of transects throughout forested (including forested wetlands) and field areas within all units of the park. The 10 meter width adjacent to trail and roadsides, other than the Colonial Parkway, and the ~75 meter width adjacent to the Colonial Parkway were inventoried separately from the adjoining habitat. Invasive species coverage was mapped using a combination of techniques, including GPS technology, aerial photography, and hand mapping. Once mapped, species were prioritized for management action based on their level of threat and feasibility of control.

Two years of field work included inventory of the following: 1) All forested areas (including forested wetlands) within the Yorktown, Jamestown and Green Spring units, and the Colonial Parkway corridor, 2) All fields within the Yorktown and Green Spring units and the Colonial Parkway corridor, 3) All non-forested wetlands in the Yorktown, Jamestown and Green Spring units, and the Colonial Parkway corridor, 4) The village of Yorktown. Areas excluded from inventory include mowed lawns of Jamestown Island where species identification is difficult.

In the forested areas, 24 invasive exotic species were found. Along roadsides, 39 invasive exotic species were found, and in fields, 38 invasive species were found. Species causing the greatest impact, based on the parkwide acreage they cover, are Microstegium (*Microstegium viminium*), Japanese honeysuckle (*Lonicera japonica*), Bermuda grass (*Cynodon* dactylon), tall fescue (*Festuca elatior*), Chinese privet (*Ligustrum sinense*), orchard grass (*Dactylis* glomerata), and Chinese lespedeza (*Lespedeza cuneata*). Complete control of these species throughout the park will be difficult and costly. Therefore, specific populations or areas of the park should be considered for management of these species. Highly invasive species with low coverage throughout the park should be top priorities for eradication. This includes autumn olive (*Elaeagnus umbellata*), Common reed (*Phragmites australis*), Oriental bittersweet (*Celastrus orbiculatus*), kudzu (*Puereria lobata*) and wineberry (*Rubus phoenicolasius*).

Introduction

As invasive exotic plants become an increasing threat to forests, wetlands, Natural Heritage Areas and refuges, more and more scientists and land managers are addressing the issue. These invaders have been shown to seriously damage native plant and animal communities as well as negatively impact agriculture, cultural landscapes and infrastructure. Because it is the mission of the National Park Service to "…conserve the scenery and the natural and historic objects and the wildlife…" within its parks, many national parks are working to mitigate the problem of invasive exotic species within their boundaries. In most cases, the first step to mitigation is to conduct an inventory of invasive exotic plants throughout the park.

At Colonial National Historical Park (COLO), the funding for an inventory of invasive exotics was provided, by Regional Science, for fiscal years 1999 and 2000. Additional funding was received from Regional Science for completion of the inventory in early fiscal year 2001. Planning for this inventory began in January, 1999. Its goals were to determine what invasive exotic plant species are found in COLO, prioritize species for control based on their level of threat and the feasibility of control, and develop a management plan. Field data collection began in April, 1999 and continued through mid-November, 1999. Following several months to enter data, fieldwork continued in mid-February, 2000 and ended in October, 2000. The inventory to date has included all forested areas (including forested wetlands), field areas, and non-forested wetlands throughout the park, as well as the village of Yorktown. Areas excluded from inventory include mowed lawns of Jamestown Island where species identification is difficult.

Accomplishments

- Created list of potential invasive exotic flora
- Drafted and finalized protocol to inventory park for listed species
- Created GIS database showing location of exotics and associated Access database
- Completed inventory of Yorktown, Jamestown and Green Spring units, and the Colonial Parkway Corridor.
- Inventoried all areas of the Colonial Parkway corridor.
- Completed data entry into GIS and Access databases for all inventoried areas.
- Defined priorities for invasives mitigation.

Experts in the fields of pest management, botanical inventory, and resource management reviewed the draft inventory protocol. It was necessary for the protocol to take into consideration the park's size, modes of access, exotic distribution, resource issues, and management concerns. In addition, because funding and personnel devoted to this project are limited, it was essential that time efficiency be considered in all aspects of the inventory design and execution. Therefore, it was necessary for the protocol to be tested in the field before being finalized. Throughout the 1999 field season the protocol was modified and refined as additional lessons were learned. Appendix 1 contains a list of Lessons Learned during the first year.

Methods

The inventory protocol was designed to divide the park into several categories: 1) road and trailsides (including the Colonial Parkway), 2) remaining forests (including forested wetlands) and fields within the Yorktown, Jamestown and Green Spring units, and 3) non-forested wetlands. First, because road and trailsides have a more diverse and abundant community of invasives, the 10-meter width adjacent to all roads and trails within the Yorktown, Green Spring and Jamestown units were to be sampled separately from the adjoining habitat. Along the Colonial Parkway, the Park Service owns only a thin corridor of land surrounding the road (up to approximately 75 meters on either side). For this reason, the 10 meters adjacent to the road and the adjoining habitat were combined for sampling. The invasives in road and trailside areas were recorded and mapped within equally sized strips. Portions of the Colonial Parkway significantly wider than 75 meters (i.e. Ringfield, College Creek and Neck of Land) were inventoried in the same manner as forested areas.

The remaining forests (including forested wetlands) and fields within the Yorktown and Jamestown units were divided into sections for which the boundaries could be easily viewed in the field (i.e. roads, trails, field borders, park boundaries, etc.). Each section was walked in parallel transects approximately 40 meters apart. Invasives found in these areas were mapped by hand if their locations could be referenced by permanent landmarks or aerial photography. Otherwise, they were mapped using GPS technology. Due to the difficulty and time involved in accessing many of the parks' non-forested wetlands, these areas were viewed by several vantage points along the shoreline or from boat. The location and size of non-forested wetland areas containing invasives was estimated and mapped by hand using aerial photographs and landmarks for reference.

Inside each mapped area the percent ground cover was estimated for each invasive species (as described in Appendix 2), except Microstegium and Japanese honeysuckle, and the number of stems per unit area was estimated for all invasive shrubs, vines and trees except Japanese honeysuckle. The total percent ground cover of all invasives in each mapped area was also estimated. The coverage and stem numbers for Microstegium and Japanese honeysuckle were estimated in road and trailside strips. However, the widespread distribution of these species throughout the park prevented them from being mapped, as other species, in the remaining forested and field areas because of the time this would have required.

During the first field season, in addition to the mapping phase of the inventory, 78 circular plots were randomly placed, throughout the forested areas of the Yorktown unit, to estimate the ground coverage of Microstegium and the ground coverage and number of stems per unit area for Japanese honeysuckle. However, because their widespread distributions move these species to a low priority for management, the completion of these plots was not continued in the Jamestown and Green Spring units of the park (See Appendix A for the final inventory protocol presently in use). Because invasive vegetation found in field areas tended to have no defined border other than the boundary of the field, entire fields were mapped as one area. Similarly, easily defined areas of Yorktown village, such as blocks and fields, were inventoried as entire areas.

Findings

Invasives Abundance

The series of random plots designed to determine the average percentage of the ground covered by Microstegium (*Microstegium viminium*) and Japanese honeysuckle (*Lonicera japonica*) yielded 14% and .08% respectively. The average number of stems of Japanese honeysuckle yielded by the plots was 65 per acre.

Of the remaining species, parkwide acreage was greatest for Orchard grass (*Dactylis glomerata*), followed by Bermuda grass (*Cynodon dactylon*), Chinese privet (*Ligustrum sinense*) and tall fescue (*Festuca elatior*) (Figure 1). However, if the large percentage of invasive coverage found on roadsides, trailsides and fields is removed from the equation, Chinese privet is the most abundant species. This is followed by common chickweed (*Stellaria media*), Common reed (*Phragmites australis*), and tree of heaven (*Ailanthus altissima*). The remaining species each cover less than 19 acres (see Table 1).

Invasives Distribution

Microstegium and Japanese honeysuckle are extremely widespread throughout Yorktown, Jamestown and the Colonial Parkway corridor. Japanese honeysuckle seems to have no pattern of infestation, and is rarely found in very dense patches. However, Microstegium occurs in large, dense patches in every forest opening, streamside, trailside and roadside. Aside from these species, the invasive exotics species found in COLO occur in much more patchy distributions (Table 1). Infestation by most species seems to be concentrated along roadsides, in fields, and in the northeastern section of Yorktown forests (Figure 2a and 2b). The forest infestations correspond to former homesites that were purchased by the park in the 1960s and 70s. However, there are smaller, more isolated patches of exotics on Jamestown Island (Figure 2b), the western end of Yorktown (Figure 2a), Green Spring (Figure 2c), and Ringfield (Figure 2d).

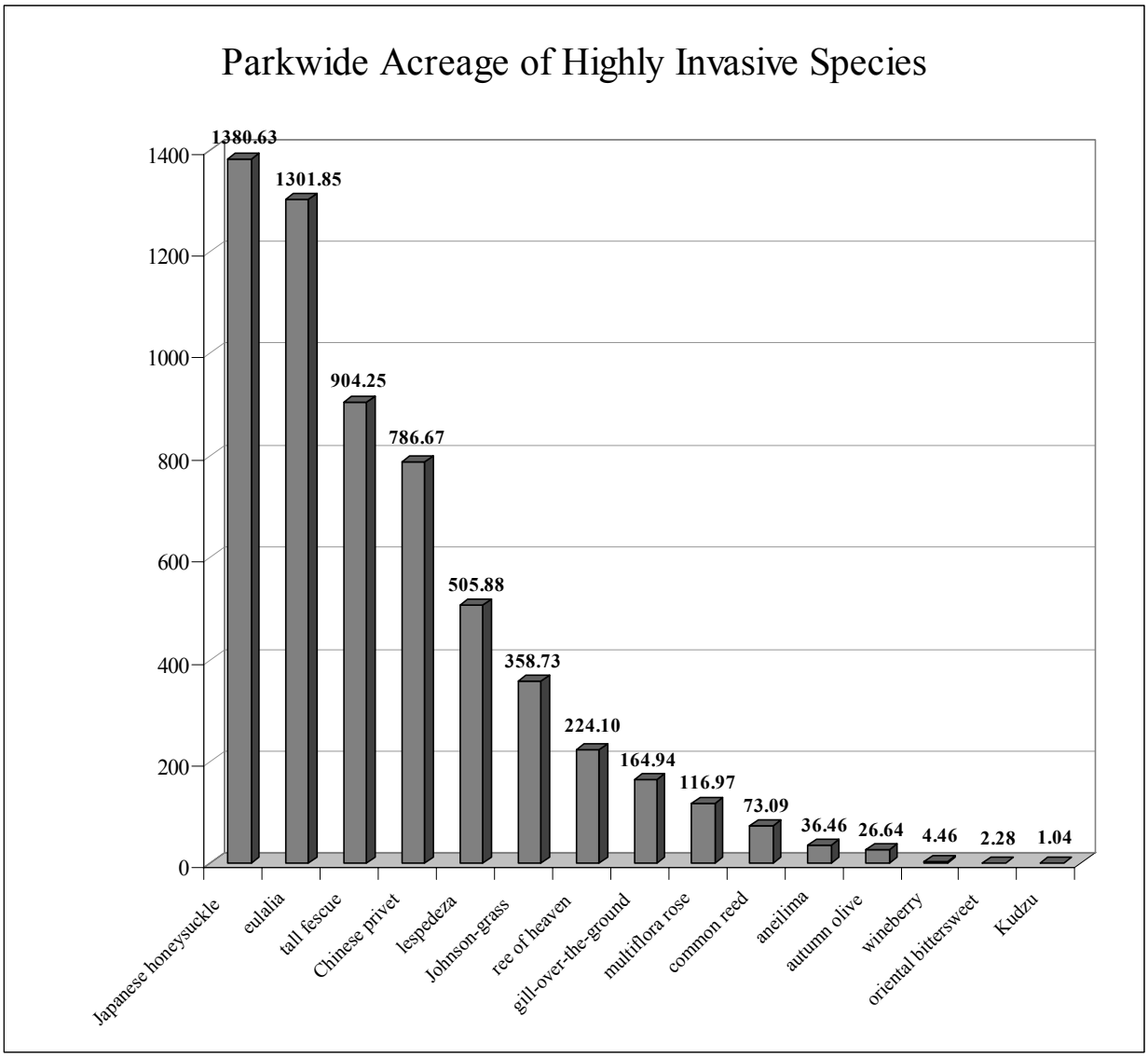


Figure 1a. The total parkwide acreage of each exotic species classified with high invasiveness.

These acreages were determined by adding the areas of mapped polygons in forests (including forested wetlands), roadside, trailside, fields and non-forested wetlands containing each invasive exotic species. Invasiveness classifications are based on the list, "Invasive Alien Plant Species in Virginia", compiled by the Virginia Division of Natural Heritage in cooperation with the Virginia Native Plant Society. However, some changes and additions were made at the advice of professionals in the field.

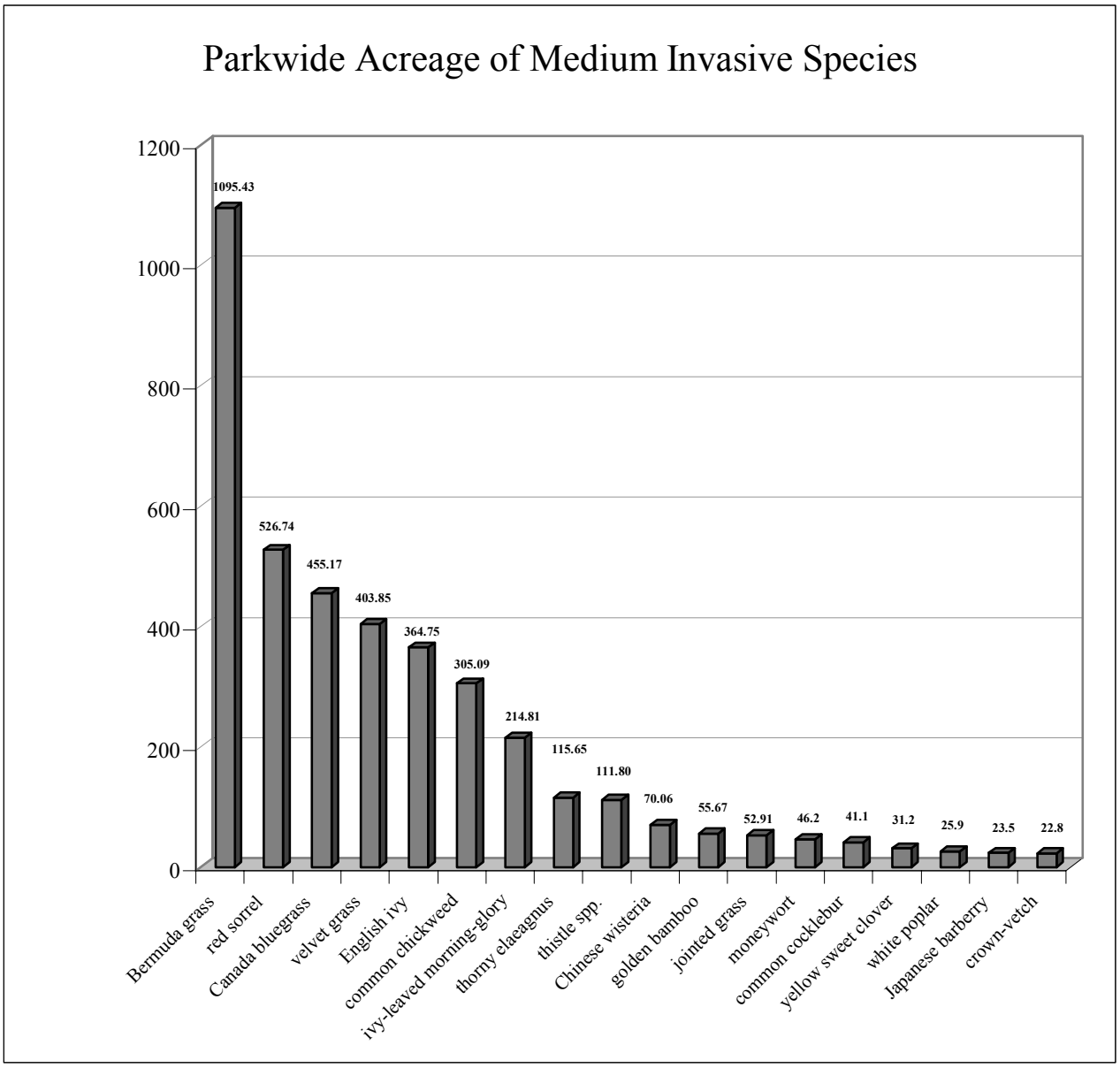


Figure 1b. The total parkwide acreage of each exotic species classified with medium invasiveness and covering > 20 acres.

These acreages were determined by adding the areas of mapped polygons in forests (including forested wetlands), roadside, trailside, fields and non-forested wetlands containing each invasive exotic species. Invasiveness classifications are based on the list, "Invasive Alien Plant Species in Virginia", compiled by the Virginia Division of Natural Heritage in cooperation with the Virginia Native Plant Society. However, some changes and additions were made at the advice of professionals in the field.

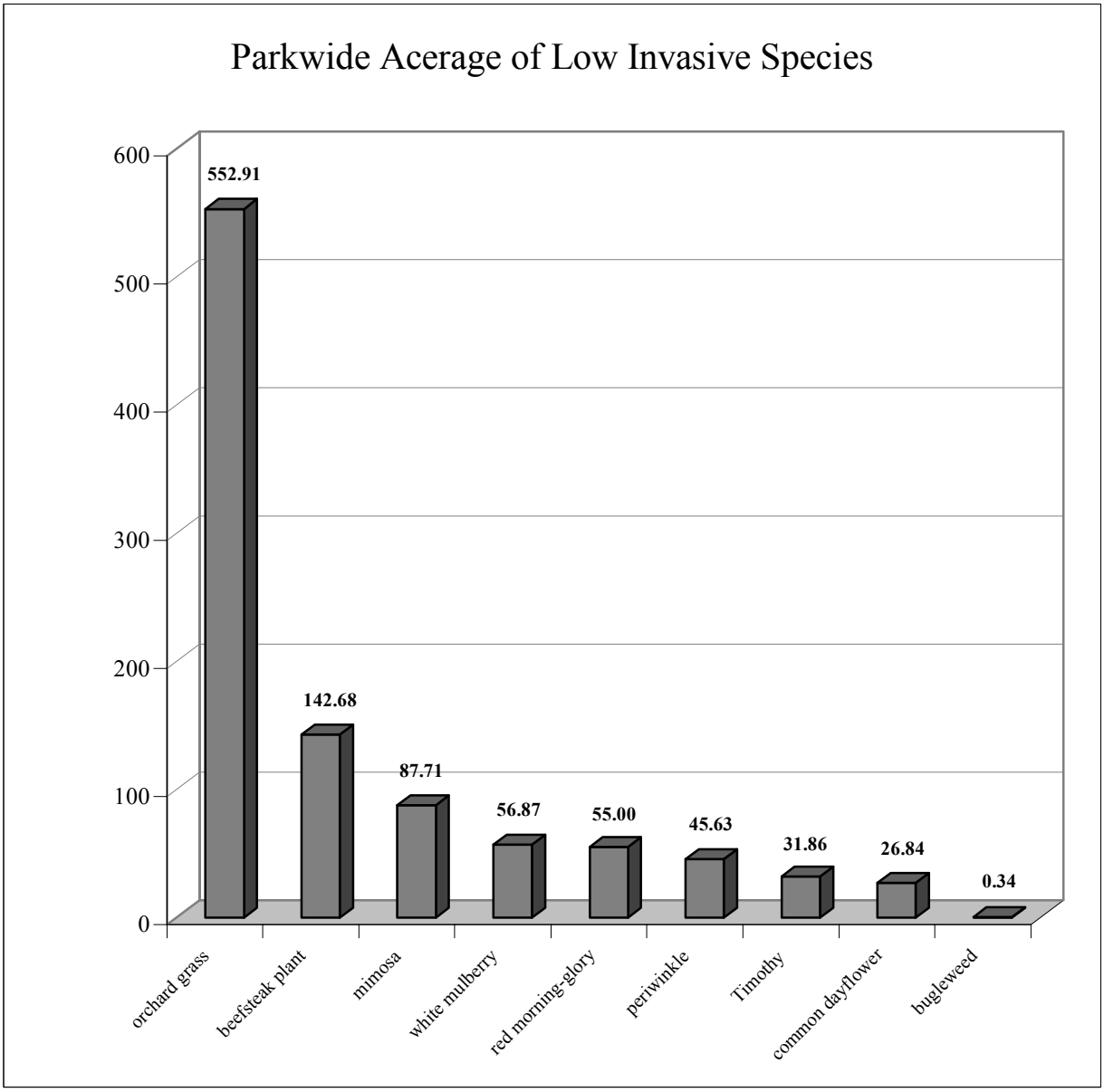


Figure 1c. The total parkwide acreage of each exotic species classified with low invasiveness.

These acreages were determined by adding the areas of mapped polygons in forests (including forested wetlands), roadside, trailside, fields and non-forested wetlands containing each invasive exotic species. Invasiveness classifications are based on the list, "Invasive Alien Plant Species in Virginia", compiled by the Virginia Division of Natural Heritage in cooperation with the Virginia Native Plant Society. However, some changes and additions were made at the advice of professionals in the field.

Table 1. Summary of invasive plant distribution throughout all sections of the park.

Species	Area (Acres)	Distribution
Aneilima (*Murdannia keisak*)	~36 ~28: fields ~8: roadsides	**Yorktown:** Found within three fields **Jamestown:** Found within <0.5 acres of roadside **Colonial Parkway:** Found within ~8 acres of parkway corridor
Autumn Olive (*Elaeagnus umbellata*)	~27	**Yorktown:** Several individuals were found scattered within ~1 acre of roadside, along the edges of 2 fields, and in yards and wooded areas of the village. **Colonial Parkway:** Individuals scattered within ~2 acres of parkway corridor **Route 17:** Planted as a hedge in the median strip and scattered individuals in the surrounding roadside.
Beefsteak plant (*Perilla frutenscens*)	~143 ~52: forests ~49: fields ~41: roadsides	**Yorktown:** Approximately 10 populations were found, five in fields, and five in open forest. It was also found within ~19 acres of roadside **Jamestown:** Five populations of relatively small size and low plant density were found in open woods and adjacent to fields **Colonial Parkway:** Found within ~22 acres of parkway corridor **Neck of Land:** Found scattered along an old route 31 **Ringfield:** One small population was found adjacent to old tour road
Bermuda grass (*Cynodon dactylon*)	~1095 ~17: forests ~386: fields ~693: roadsides	**Yorktown:** Two small populations were found in a regenerating old-field habitat a short distance from the west tour road. Also found within 23 fields and ~75 acres of roadside **Jamestown:** Found within ~16 acres of roadside **Green Spring:** Found within <1 acre of roadside **Colonial Parkway:** Found within ~601 acres of parkway corridor
Bugleweed (*Ajuga reptens*)	<1	**Yorktown:** One very small population was found adjacent to Route 637
Canada Bluegrass (*Poa compressa*)	~455 ~265: fields ~166: roadsides ~3: trailside ~21: forest	**Yorktown:** Found within 22 fields, ~11 acres of roadside, ~3 acres of trailside, and in yards and wooded areas of the village **Jamestown:** Found within ~2 acres of roadside **Green Spring:** Found within ~2 acres of roadside **Colonial Parkway:** Found within ~150 acres of parkway corridor
Chinese Lespedeza (*Lespedeza cuneata*)	~506 ~3: forests ~333: fields ~169: roadsides <1: trailsides	**Yorktown:** One small population was found in a regenerating old-field habitat a short distance from the west tour road and in two other fields, generally along earthworks and infrequently mowed areas. It was also found within ~26 acres of roadside **Jamestown:** Found within ~3 acres of roadside **Green Spring:** Two dense populations found in early successional area adjacent to a field **Colonial Parkway:** Found within 131 of parkway corridor **Neck of Land:** Found in one small population and along old route 31

Species	Area (Acres)	Distribution
Chinese Privet (*Ligustrum sinense*)	~787 ~282: forests ~371: roadsides <1: trailsides ~132: fields	**Yorktown:** Greater than 20 populations were found concentrated in forest and streamside habitats on the eastern side of Yorktown. Common in wooded areas of the village. Populations were typically large and consisted of many large individuals. It was also found within ~47 acres of roadside. Common along wooded edges of fields. **Jamestown:** Four small populations of low plant density were found on the western end of the island. Individuals were all relatively small. It was also found within ~1 acre of roadside **Green Spring:** One large population was found adjacent to a field **Colonial Parkway:** Found within ~320 acres of parkway corridor **Neck of Land:** Two large and two small populations were found in old homesite areas. It was also found along old route 31
Chinese Wisteria (*Wisteria sinensis*)	~70 ~9: forests ~8: roadsides ~53: fields	**Yorktown:** Nine populations were found along roadsides (covering ~26 acres of roadside), three of which extend into forest habitat **Colonial Parkway:** Nine populations were found within the parkway corridor (covering ~6 acres), three of which were relatively large **Ringfield:** One large, densely distributed population was found adjacent to the old tour road
Common Chickweed (*Stellaria media*)	~305 ~129: forests ~145: fields ~23: roadsides ~7: trailsides	**Yorktown:** Nearly 20 populations of varying size and plant density were found along streamsides and in disturbed forest habitat. It was also found within 2 fields ,~16 acres of roadside, ~7 acres of trailside, and within the village. **Jamestown:** Greater than 20 populations of varying size and plant density were found in disturbed forest habitat. It was found within <1 acre of roadside **Green Spring:** Three large populations were found adjacent to fields, and one small population was found along a streamside. **Colonial Parkway:** Found within ~6 acres of parkway corridor
Common Cocklebur *(Xanthium strumarium)*	<1	**Yorktown:** A single small population found along the earthworks at southern edge of in field 22
Common Dayflower (*Commelina communis*)	~27 ~12: forest ~5: field ~9: roadside	**Yorktown:** A small population found within one field. Also found within ~ 9? Acres of roadside. **Colonial Parkway:** Found sparsely within ~7 acres of parkway corridor
Common reed (*Phragmites australis*)	~73	**Yorktown:** One large population was found lining the northwest tributary of Wormley pond. A much smaller population was found at the southern end of Yorktown Creek **Jamestown:** Ten populations of varying size and density were found distributed throughout the Jamestown wetlands **Colonial Parkway:** Three extensive populations were found (Mill Creek, College Creek and adjacent to Naval Weapons Station) along with several small populations, within ~50 acres of parkway corridor **Ringfield:** One small population was found lining a creek Tributary **Neck of Land:** Four small populations and one larger population were found in the non-forested wetlands west of the forested area. Several of these populations located within the Neck-O-Land Natural Heritage Area.
Crownvetch (*Coronilla varia*)	<1	**Yorktown:** Found in one field **Colonial Parkway:** Found within <0.5 acres of parkway corridor

Species	Area (Acres)	Distribution
English Ivy (*Hedera helix*)	~365 ~76: forests ~113 roadsides <1: trailsides ~175: fields	**Yorktown:** More than ten populations of varying size and plant density were found on the eastern end of the park. It is common in the village. It was also found within ~9 acres of roadside. **Green Spring:** One small population found adjacent to field **Colonial Parkway:** Found, often densely distributed, within ~103 acres of the parkway corridor. **Neck of Land:** One small and 1 large population found in two old homesite areas
Gill Over the Ground (*Glechoma hederacea*)	~165 ~30: forests ~98: roadsides <1: trailsides ~36: fields	**Yorktown:** Four relatively small populations were found in disturbed forest, in addition to small populations scattered throughout the village. It was also found within ~5 acres of roadside and in low density in 2 fields. **Jamestown:** Eight relatively small populations were found in disturbed forest and along fieldsides. It was also found within ~5 acres of roadside. **Green Spring:** Two large populations were found adjacent to a field **Colonial Parkway:** Found within ~86 acres of parkway corridor **Ringfield:** One small population was found in forested area **Neck of Land:** Found along old route 31
Golden Bamboo (*Phyllostachys aurea*)	~56 ~31: forests ~25: roadsides	**Yorktown:** Eleven* populations were found lining steep slopes, within roadside (~2 acres) and in areas of past or present development. Eight of the 11 populations are extremely mature with many large individuals. **Jamestown:** Nine small populations* were found along roadsides (~4 acres). Most individuals have not yet reached two meters in height. One mature population was found near the glasshouse and Jamestown entrance road. **Colonial Parkway:** Twenty small concentrations were found within ~18 acres of the parkway corridor * **Neck of Land:** One large population was found in old homesite area * It is likely that populations recorded as being immature or "small" are actually populations of native cane *Arundinaria sp.*, which was initially confused with bamboo in surveys. Identity of populations should be confirmed before mitigation actions are taken.
Japanese Barberry (*Berberis thumbergii*)	~1 <1: forest <1: roadside <1: field	**Yorktown:** A small population was found in a single field and another single shrub was found in the forest adjacent to Route 238 near the trailer park **Jamestown:** Four small populations were found just south of the first turnout along the loop road
Japanese Honeysuckle (*Lonicera japonica*)	Parkwide	Dispersed, most often sparsely, throughout all areas of the park
Japanese Knotweed *(Polygonum cusidatum)*	~19 ~5: fields ~13: forest <1: roadsides	**Yorktown:** Five small patches were found in the village and vicinity of the visitors center, as well as one small patch within roadside.
Japanese Stiltgrass (*Microstegium viminium*)	Parkwide	Densely distributed throughout all roadsides, stream corridors, trailsides, and forest openings

Species	Area (Acres)	Distribution
Johnson grass (*Sorghum halapense*)	~359 ~3: forest ~312: fields ~42: roadsides ~1: trailsides	**Yorktown:** One population was found in an old landfill area adjacent to the southern end of the east tour road. It was also found sparsely distributed within ~17 acres of roadside and in small patches within 4 fields. **Jamestown:** Found sparsely distributed within ~2 acres of roadside **Green Spring:** Found within ~3 acres of roadside **Colonial Parkway:** Found within ~18 acres of parkway corridor **Neck of Land:** Several clumps found along old route 31
Jointed grass *(Arthraxon hispidus)*	~53	**Yorktown:** Found within 9 fields, usually in poorly drained areas
Kudzu (*Pueraria lobata*)	~1	**Colonial Parkway:** One population was found adjacent to the Williamsburg entrance ramp **Yorktown:** A single vine was near bank of York River along edge of field #1A
Mimosa (*Albizzia julibrissin*)	~88 ~18: forests ~44: fields ~26: roadsides	**Yorktown:** Trees and seedlings were scattered within ~5 acres of roadside, including ~2 acres of route 17. Several seedlings were found in three fields. Also found two small patches within wooded areas of the village **Colonial Parkway:** Trees and seedlings were scattered within ~21 acres of parkway corridor **Neck of Land:** One reproducing individual found along old route 31
Moneywort *(Lysimachia nummularia)*	~46 ~22: roadside ~24: field	**Yorktown:** Found within a single field **Colonial Parkway:** Found within ~2 acres of parkway corridor
Morning-glory spp. (*Ipomoea purpurea*, *coccinea* and *hederacea*)	~12	**Yorktown:** Found sparsely distributed throughout <0.5 acre of roadside. **Colonial Parkway:** Found sparsely distributed throughout ~12 acres of parkway corridor
Multiflora Rose (*Rosa multiflora*)	~117 ~14: forests ~60: roadsides ~43: fields	**Yorktown:** areas of low plant density were found within ~6 acres of roadside, eight of which extend into forest and field edges. Also found along the periphery of one additional field. **Jamestown:** Three populations were found within ~1 acre of roadside **Colonial Parkway:** Found scattered within ~51 acres of parkway corridor **Neck of Land:** Two small populations were found in a forest opening and along old route 31 **Green Spring:** One large population was found adjacent to a field and two concentrations were found within ~1 acre of roadside
Orchard grass (*Dactylis glomerata*)	~553 ~13: forests ~472: fields ~68: roadsides	**Yorktown:** Found in low density in 20 fields and ~16 acres of roadside **Jamestown:** Found in ~2 acres of roadside **Green Spring:** Found in 1 large population adjacent to field and in ~2 acres of roadside **Colonial Parkway:** Found in ~48 acres of roadside **Ringfield:** Found in two large old field habitats
Oriental Bittersweet (*Celastrus orbiculatus*)	~3 <1: forests ~3: roadsides	**Yorktown:** One small population was found in the forest adjacent to Moore House Road within <0.1 acre of roadside **Colonial Parkway:** Three small populations were found within ~2 acres of parkway corridor
Periwinkle (*Vinca minor*)	~46 ~26: fields ~16: forests ~4: roadsides	**Yorktown:** Found in <0.5 acres of roadside and common throughout forested areas of the village. **Green Spring:** Found in 1 field.

Species	Area (Acres)	Distribution
Princess tree (*Paulonia tomentosa*)	~18 ~12: forests ~6: roadsides	**Yorktown:** Four small populations were found in forest habitat on the western side of Yorktown and one small population in the village. It was also found in <0.1 acre of roadside. **Jamestown:** Greater than 20 populations were found distributed throughout the forest. The majority of the populations were small and of low plant density. Individuals were also found scattered in <1 acre of roadside **Colonial Parkway:** Individuals were scattered through ~5 acres of parkway corridor **Ringfield:** Several trees found along the old tour road
Red Sorrel (*Rumex acetosella*)	~527 ~1: forests ~516: fields ~9: roadsides	**Yorktown:** Found in five fields <1 acre of roadside **Jamestown:** Found in <1 acre of roadside **Green Spring:** Found in both fields, a large, open area adjacent to a field, and in <0.5 acres of roadside **Colonial Parkway:** Found in ~8 acres of parkway corridor
Sweet-clover spp. (*Melilotus alba* and *officinalis*)	~46 ~27: fields ~17: roadsides ~2: forest	**Yorktown:** Found in low density within 15 fields and ~1 acre of roadside **Green Spring:** Found in <0.5 acre of roadside **Colonial Parkway:** Found in ~16 acres of roadside
Tall Fescue *(Festuca elatior)*	~904 ~512: fields ~23: forest ~365: roadsides ~4: trailside	**Yorktown:** Found in varying density in greater than 22 fields. **Throughout Park:** Relatively common along shaded grassy roadsides.
Thistle spp. (*Cirsium arvense* and *vulgare*)	~112 ~108: field ~4: roadsides	**Yorktown:** Found in ~4 acres of roadside and in low density in five fields where it is usually concentrated along earthworks
Thorny Elaeagnus (*Elaeagnus pungens*)	~65 ~2: forests ~54: fields ~9: roadsides	**Yorktown:** Five relatively small populations of low plant density were found in forest habitat throughout Yorktown. Individuals were also scattered throughout two fields and ~1 acre of roadside **Colonial Parkway:** Individuals scattered throughout ~8 acres of parkway corridor, with a concentration around the Williamsburg entrance ramp
Timothy (*Phleum pratense*)	~32 ~25: fields ~6: forest ~1: roadside	**Yorktown:** Found in <1 acre of roadside and in low density in one field. Also found in low density in one wooded are of the village. **Green Spring:** Found in <1 acre of roadside
Tree of Heaven (*Ailanthus altissima*)	~224 ~71: forests ~77: fields ~76: roadsides	**Yorktown:** Greater than ten populations were found in open or disturbed forest habitat. The majority of the populations were large and consisted of many large individuals or densely distributed saplings. It was found in 1 field and in ~5 acres of roadside **Jamestown:** Seven populations were found in open forest habitat. Several of the populations were large and consisted of many large individuals or densely distributed saplings. Individuals were also found in ~1 acre of roadside **Green Spring:** Two small populations were found in <1 acre of roadside **Colonial Parkway:** Found in many populations of variable size and density throughout ~96 acres of the parkway corridor. Populations were densely concentrated around the Williamsburg entrance ramp **Neck of Land:** Small populations were found in a forest opening and adjacent to old route 31 **Ringfield:** One small population was found adjacent to old tour road

Species	Area (Acres)	Distribution
Velvet grass (*Holcus lanatus*)	~404 ~4: forests ~344: fields ~56: roadsides <1: trailsides	**Yorktown:** Several small populations were found in a regenerating old-field habitat a short distance from the west tour road. It was also found in 8 fields and in ~39 acres of roadside **Jamestown:** Found in ~2 acres of roadside **Green Spring:** Found in <1 acre of roadside **Colonial Parkway:** Found in ~15 acres of roadside
White Mulberry (*Morus alba*)	~57 ~16: roadsides ~24: forest ~17: fields <1: trailsides	**Yorktown:** Individual trees scattered throughout ~6 acres of roadside, <1 acre of trailside, and along the periphery of one field. Also found within wooded areas of the village and the eastern portions of Yorktown. **Green Spring:** Individual trees scattered throughout <0.5 acres of roadside **Colonial Parkway:** Individual trees scattered throughout ~9 acres of parkway corridor
White Poplar (*Populus alba*)	~26 ~7: roadsides ~10: forest ~9: fields <1: trailsides	**Yorktown:** Populations found adjacent to Cook Road (<1 acre of roadside), the trail to Washington Headquarters and in wooded areas and yards within the village. **Colonial Parkway:** Five small, and 1 large grove were found within ~6 acres of parkway corridor
Wineberrry (*Rubus Phoenicolasius*)	~5 ~1: forests ~4: roadsides	**Jamestown:** Five populations of low density were found in light gaps of relatively dry forest habitat. Seven small populations were also found within ~1 acre of roadside **Green Spring:** One population was found adjacent to roadside **Colonial Parkway:** Seven small populations were found within ~2 acres of parkway corridor

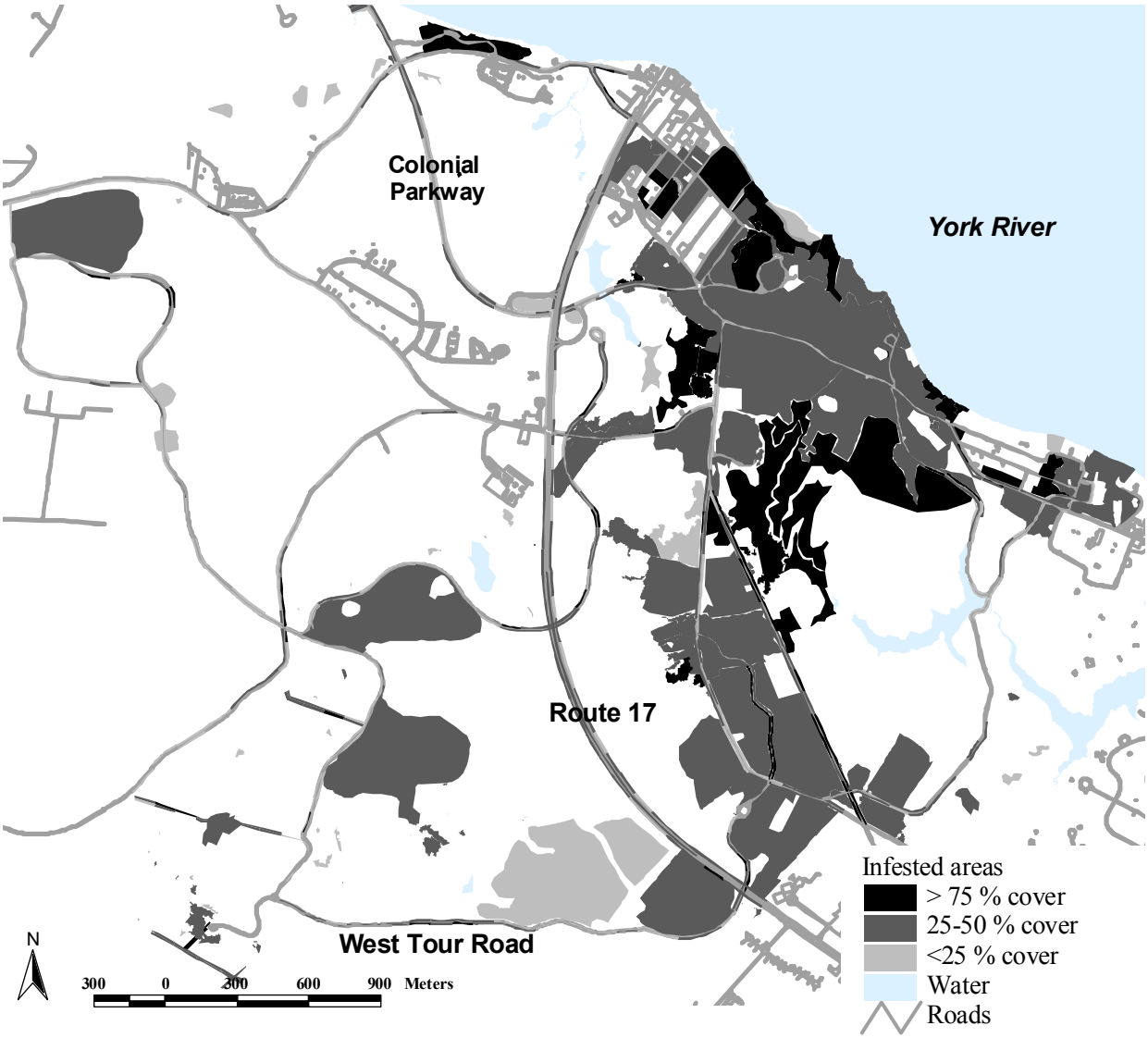


Figure 2a. Aerial distributions of areas containing invasives in Yorktown.
Infested Areas are classified according to their percent ground cover of invasive species.

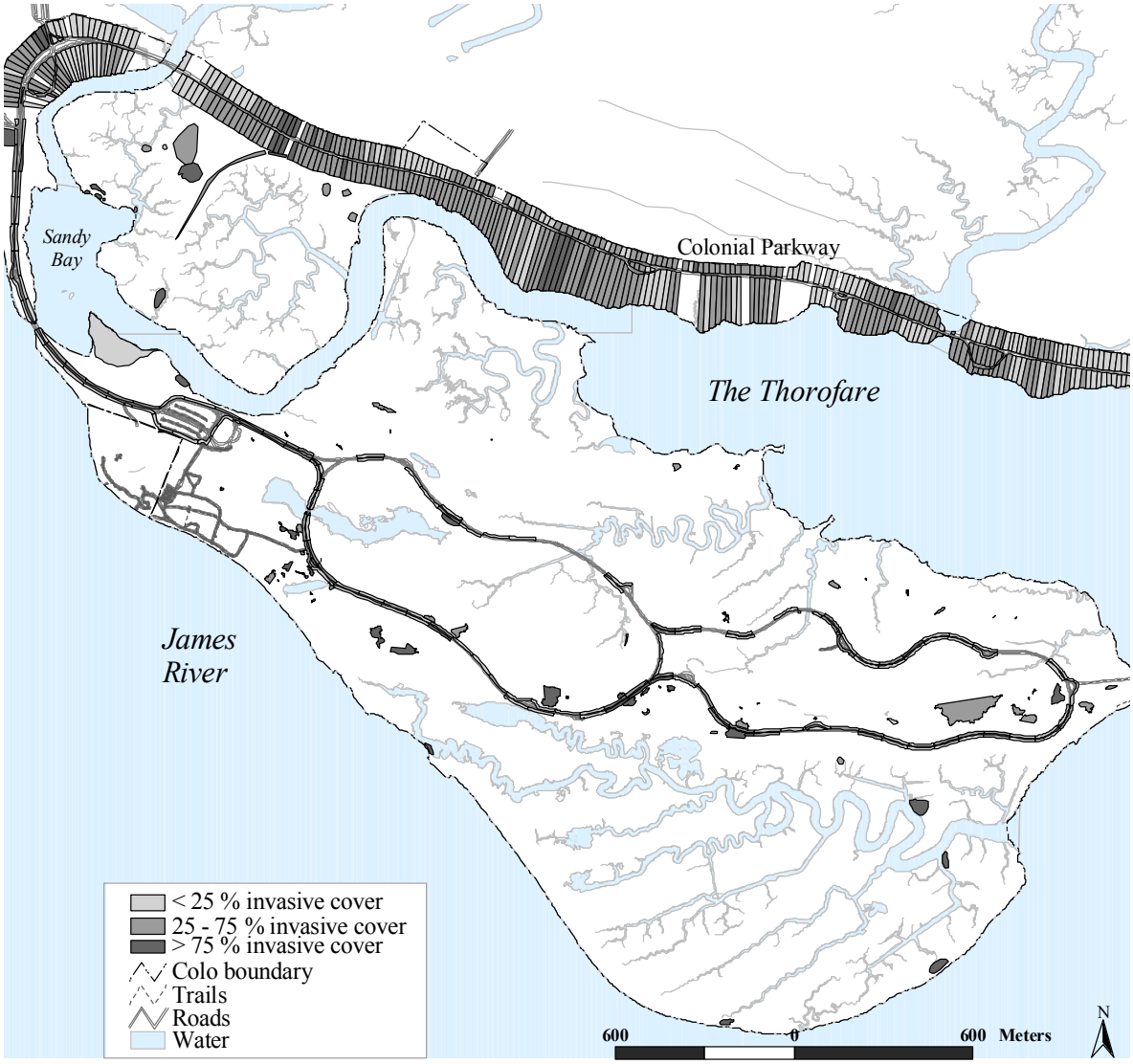
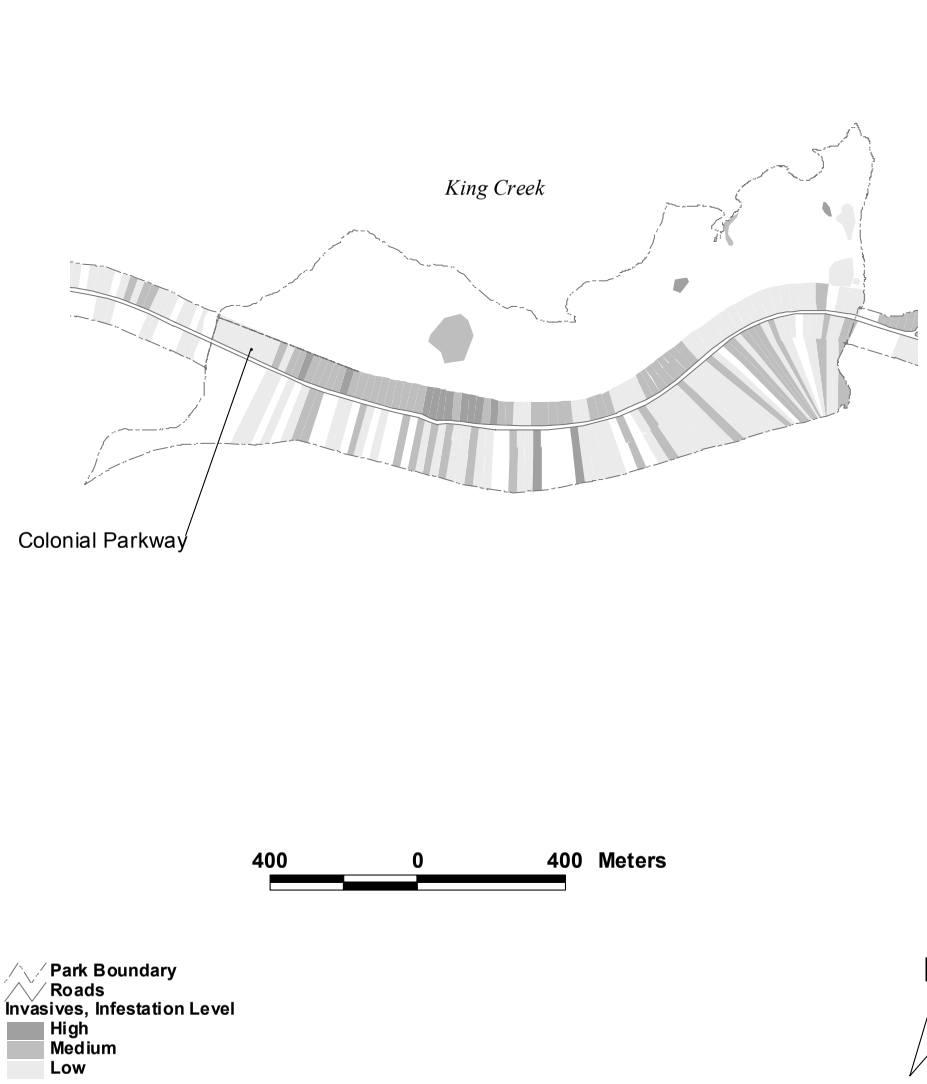


Figure 2b. Aerial distributions of areas containing invasive plants on Jamestown Island. Infested Areas are classified according to their percent ground cover of invasive species.



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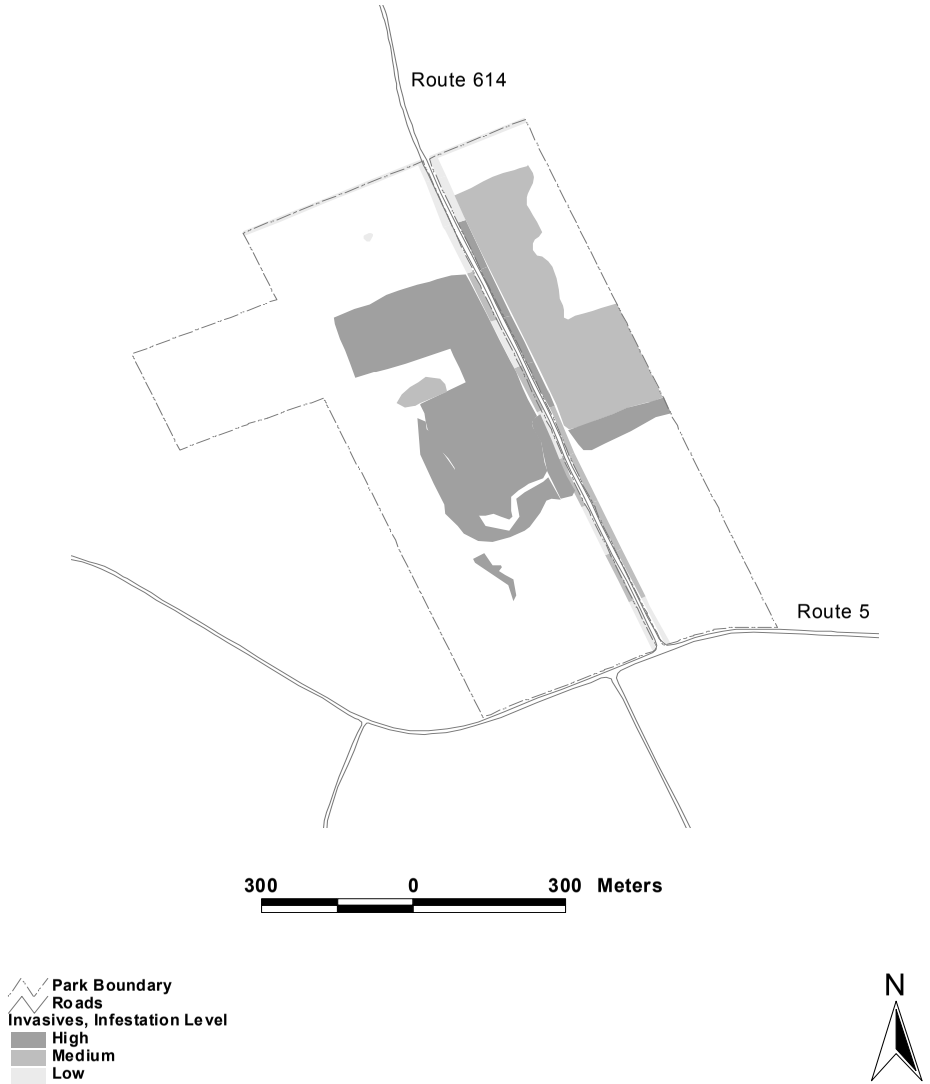


D.

Figures 2c and 2d . Aerial distributions of areas containing invasive plants in the Kings Creek (C.) and Green Spring (D.) units.

Infested areas were categorized by Infestation Level (High = >75% Ground Cover by invasives; Medium = 25-75% Ground Cover by invasives; Low = <25% Ground Cover by invasives).

Invasives in Special Status Areas

Special Status Areas include Natural Heritage areas as defined in *A Natural Heritage Inventory of Mid-Atlantic Region National Parks in Virginia: Colonial National Historic* Park (Ludwig et al. 1993) as well as areas being considered for recommendation as Natural Heritage areas due to the recent discovery of rare, threatened, or endangered species, and areas of particular cultural and historical concern.

Many small, infested areas exist within the **Beaverdam Creek Natural Heritage Area** (Figure 3a). In addition, populations of Microstegium and common chickweed cover relatively large areas within this Natural Heritage Area. Exotic species found in this Natural Heritage Area include:

- Common chickweed
- Empress tree
- Beefsteak plant
- Chinese wisteria
- Gill-over-the-ground
- Chinese lespedeza
- Bermuda grass
- Multiflora rose
- Thorny Elaeagnus
- Tree-of-heaven
- Velvet grass
- Chinese privet
- Microstegium
- Japanese honeysuckle

Several large, infested areas encroach into the **Wormley Pond Area** from the north (Figure 3a). Microstegium and Japanese honeysuckle are present throughout. The list of species found in the Wormley Pond Area include:

- Common reed
- English ivy
- Microstegium
- Japanese honeysuckle

Several small, infested areas exist (Figure 3b) in the northernmost wooded areas of the **Jamestown Island Natural Heritage Area**. In addition, populations of Microstegium and common chickweed cover relatively large areas within this Natural Heritage Area. Exotic species found in this Natural Heritage Area include:

- Common chickweed
- Empress tree
- Tree-of-heaven
- Wineberry
- Gill-over-the-ground
- Common reed
- Golden bamboo
- Japanese barberry
- Microstegium
- Japanese honeysuckle

The corridor of NPS land surrounding the Colonial Parkway runs through two Natural Heritage Areas: Bracken's Pond Natural Heritage Area and Cheatham Ravines Natural Heritage Area. Invasive exotics found within the **Bracken's Pond Natural Heritage Area** include:

- Tree of Heaven
- Oriental bittersweet
- Gill-over-the-ground
- English ivy
- Common morning glory
- Chinese privet
- Japanese honeysuckle
- Microstegium
- Princess tree
- Beefsteak plant
- Common reed
- Multiflora rose
- Johnson grass
- Chinese wisteria

The invasive exotics found the **Cheatham Ravines Natural Heritage Area** include:

- Tree of Heaven
- Mimosa
- Bermuda grass
- Gill-over-the-ground
- Ivy leaved morning glory
- Common morning glory

- Chinese lespedeza
- Chinese privet
- Japanese honeysuckle
- White sweet clover
- Microstegium
- Princess tree
- Beefsteak plant
- Johnson grass

Several infested areas exist within the proposed **Neck-O-Land Natural Heritage Area** (Figure 3c). These areas include the following species:

- Chinese privet
- Common reed
- Tree of Heaven
- Mimosa
- Bermuda grass
- Aneilima
- Gill-over-the-ground
- Johnson grass
- Multiflora rose
- Tall fescue
- English ivy
- Golden bamboo
- Chinese lespedeza
- Orchard grass
- White sweet clover
- Canada bluegrass
- Japanese honeysuckle
- Beefsteak plant
- Microstegium

Many earthworks in Yorktown are covered with invasive species populations. These species include:

- Gill-over-the-ground
- English ivy
- Chinese privet
- Japanese honeysuckle
- Microstegium
- Beefsteak plant
- Golden bamboo
- Multiflora rose

- Chinese wisteria
- Common chickweed
- Tree of heaven
- Japanese barberry
- Wineberry
- Johnson grass

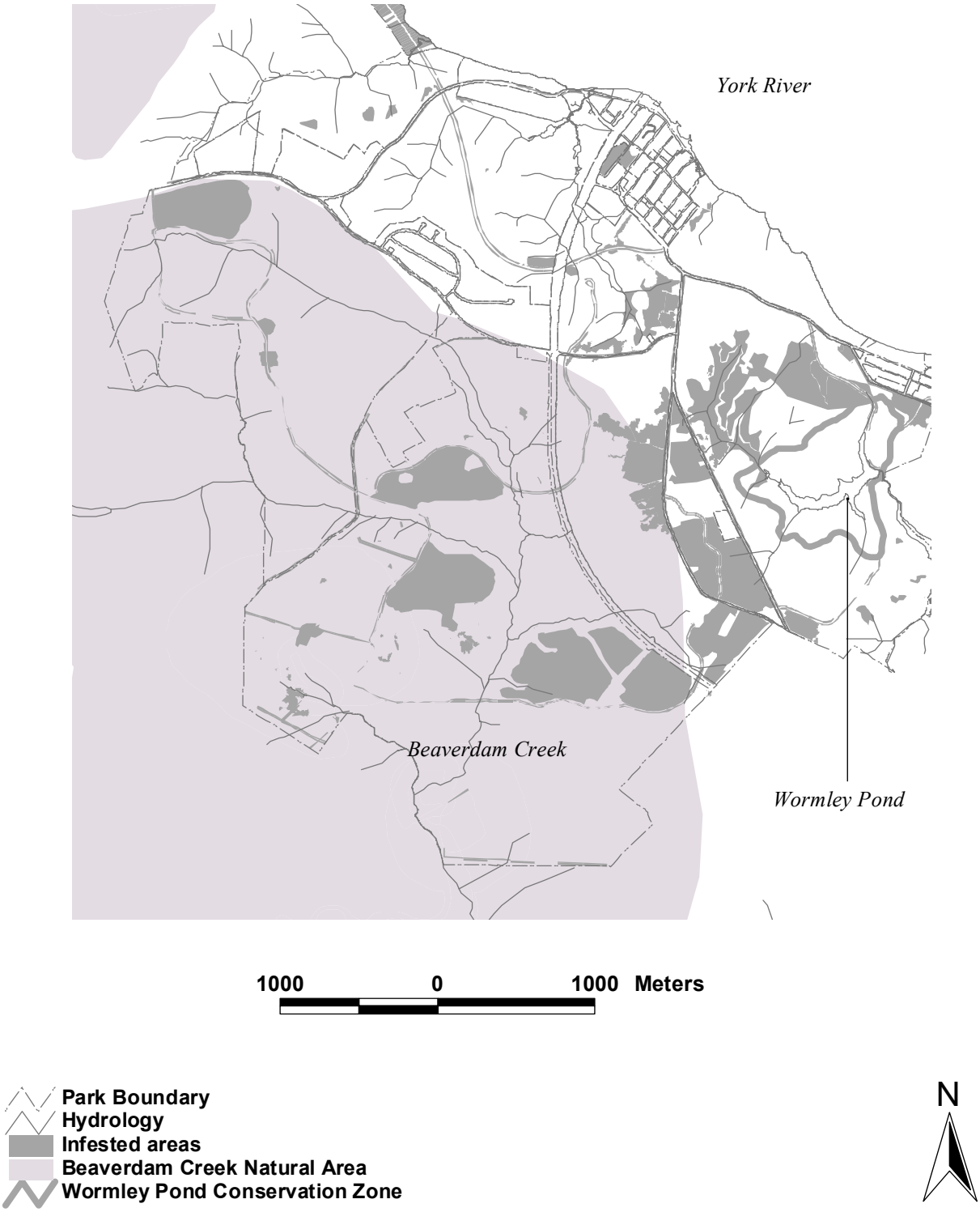


Figure 3a. The areas containing natural heritage resources in Yorktown and the distribution of infested areas within them.

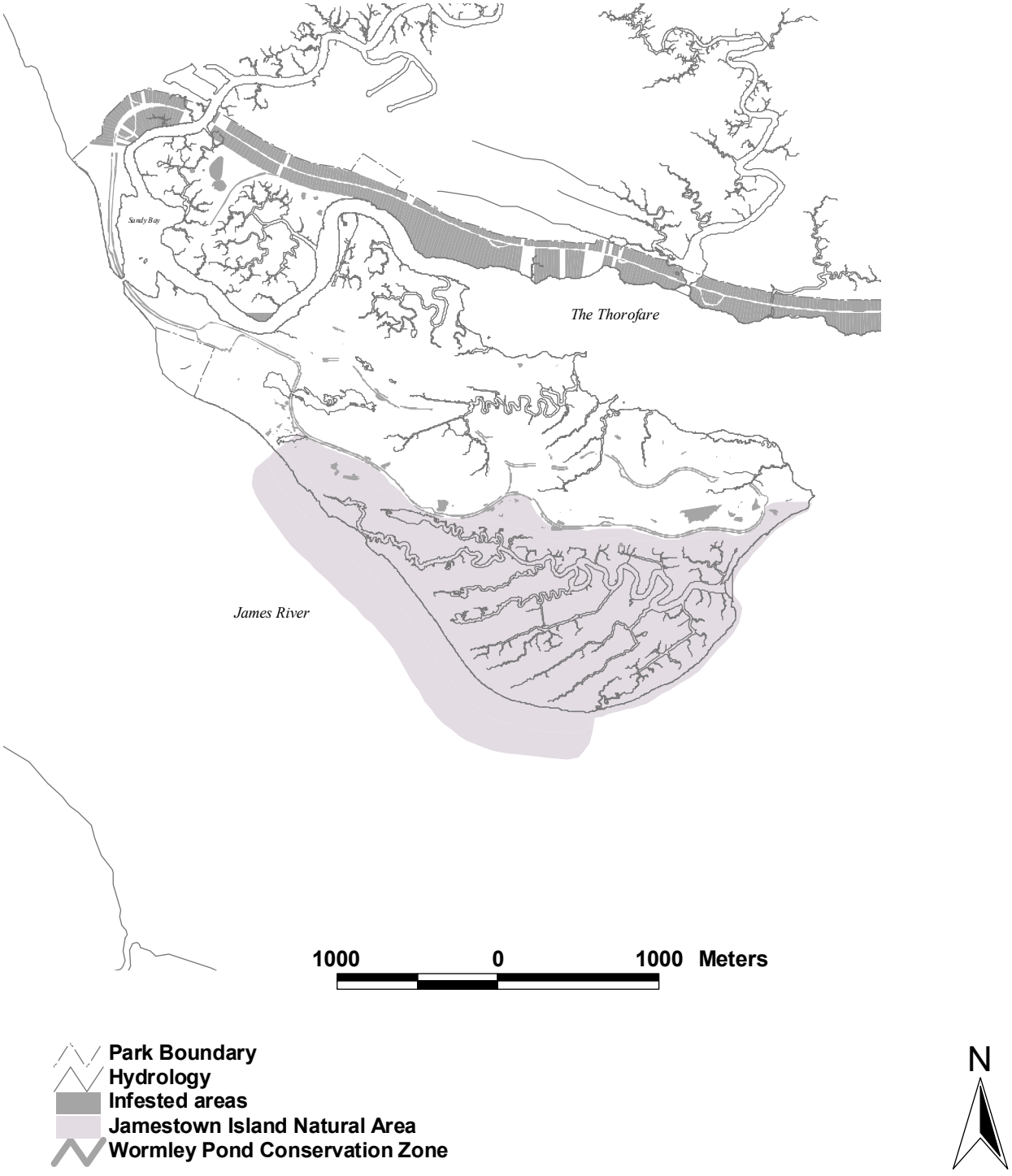


Figure 3b. The distribution of infested areas within the Jamestown Island Natural Heritage Area.

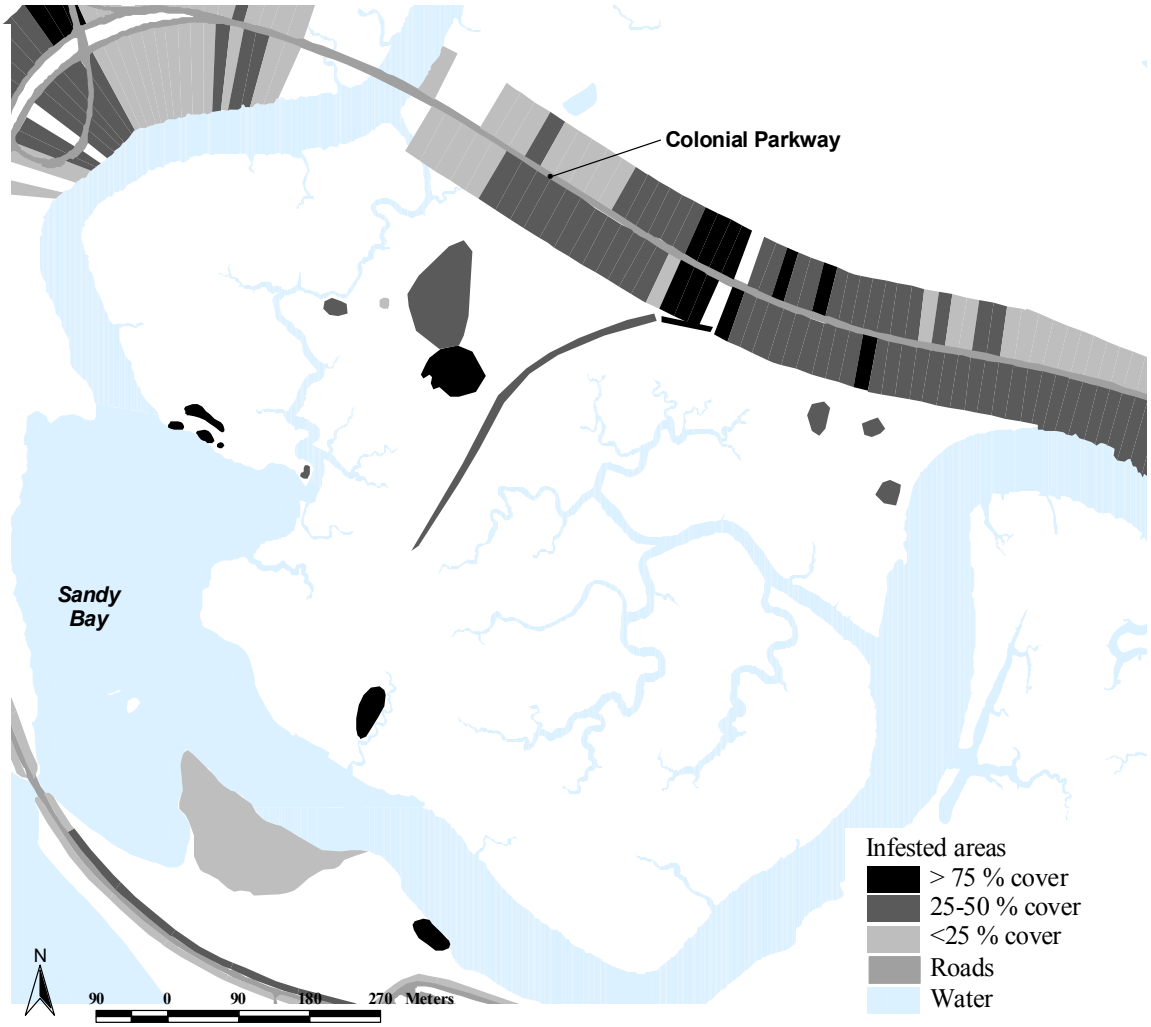


Figure 3c. The distribution of infested areas within the proposed Neck-O-Land Natural Heritage Area.

Preliminary Management Implications

Priorities for Management

Exotic species prioritization will generally follow the *Handbook for Ranking Exotic Plants for Management and Control* (Hiebert and Stubbendieck). Using the handbook species are ranked based on biological threat and feasibility of control:

- Species with a high biological threat and easy control are considered the first priority;
- Species with a high biological threat and more difficult control are the second priority;
- Species with low biological threat and easy control are the third priority;
- Species with low biological threat and more difficult control are fourth priority.

The biological threat of a species is based on the invasiveness classifications shown in Figure 1. Plants classified as highly invasive are all biologically difficult to control due to either 1) their ability to sprout from stems and roots, or 2) the long lasting viability of their seeds in the soil. For this reason, feasibility of control for each species is based on its aerial coverage (number of acres). Within species priorities, the number and location of species populations and any management concerns will be used to prioritize specific populations for control (Appendix 3).

Priority 1: Classified as highly invasive while covering a relatively low percentage of the park:

- Autumn olive
- Oriental bittersweet
- Kudzu
- Wineberry
- Aneilima

Priority 2: Classified as highly invasive and cover a relatively high percentage of the park:

- Tree of Heaven
- Tall fescue
- Johnson grass
- Gill over the ground
- Microstegium
- Chinese privet
- Japanese honeysuckle
- Multiflora rose
- Common reed

Because Priority 2 species are so widespread throughout the park, it is unrealistic to expect complete eradication of these species. It is more realistic to choose specific populations for removal, or areas of the park inside which these species can be controlled. For example, areas that are critical habitats for rare, threatened or endangered plant populations or communities should be kept free of invasive exotics (RTE's). This includes Beaverdam Creek Natural

Heritage Area, which contains Florida adder's-mouth and Spanish moss, the Wormley Pond area containing lax hornpod, sandpaper vervain and dry calcareous forest, and the proposed Neck-O-Land Natural Heritage Area containing sensitive joint vetch. It also includes Cheatham and Queen Creek Natural Heritage Areas adjacent to the parkway, which contain chinkapin oak woodland, Loesel's twayblade, mountain camellia, tidal brackish marsh and Southern mixed hardwood forest. In addition, small, isolated patches of invasive exotics should be removed to limit spread throughout the park. Because large, highly visible populations of tree of heaven and Chinese privet will require removal of dead plants followed by re-vegetation, this in turn requiring a great deal of time, money and personnel, it may be necessary to move these populations to priority 3.

Priority 3: Characterized by medium invasiveness, while covering a relatively low percentage of the park:

- Golden bamboo
- Moneywort
- Sweet clover spp.
- Princess tree
- White poplar
- Japanese barberry
- Thistle spp.
- Crownvetch
- Chinese wisteria

Specific populations of bamboo may need to be prioritized. A single, relatively small population near the glasshouse on Jamestown Island is small and may be more manageable. However, three populations in Yorktown are large, dense, and highly visible and are responsible for stabilizing the soil they are growing on. These populations should be a lower priority due to the expense and resources involved in removal and re-vegetation, though even smaller sites are likely to require some re-vegetation.

Priority 4: Characterized by medium invasiveness, while covering a relatively high percentage of the park:

- Common chickweed
- English ivy
- Canada bluegrass
- Red Sorrel
- Velvet grass
- Chinese lespedeza
- Bermuda grass

It is unlikely that these species will be completely eradicated. However, they need to be kept out of areas in which they threaten heritage occurrences. Because chickweed is often mixed with native herbs, any herbicide must be applied with great care, and hand pulling may be necessary

in some areas. In addition, small isolated populations of these two species should be removed as soon as possible in order to minimize spread throughout the park.

Priority 5: Characterized by low invasiveness while covering a relatively low percentage of the park:

- White mulberry
- Bugleweed
- Timothy
- Common dayflower
- Morning-glory spp.
- Periwinkle
- Beefsteak plant
- Mimosa
- Thorny Eleagnus

White mulberry is thought to be a cultural resource and should left alone until further notice.

Several of the species in Priorities 1 through 6 are found primarily in dry, sunny habitats such as mowed fields and roadsides. Because these areas of the park are heavily maintained and primarily made up of exotic species, they and the species inhabiting them should be a low priority for management outside of implementation of the management plan provided by Brian Watts (see credits).

Additional Management Concerns

There are several additional issues to consider in managing invasive exotic plants at COLO:

- If an infested area lies in, or in close proximity to, an aquatic habitat, chemical control should be discouraged. However, if chemicals are necessary, a brand must be used which is specifically created for use around water.

- Infested areas located within the Natural Heritage Areas should be managed without disturbance to RTE's. It will be necessary to avoid management actions until nesting times are over for bald eagle, blue heron, and least bittern in the Beaverdam Creek and Jamestown Island Natural Heritage Areas. In other Natural Heritage Areas, native vegetation should be disturbed as little as possible. *Conservation Planning for Natural Areas of Colonial National Historic Park, Virginia* (Clark and Rafkind 1998) should be consulted before planning management in these areas.

- Any method of control causing disturbance to cultural resources (including the village of Yorktown) should be discouraged. This may mean that pulling or digging of exotic plants should be avoided without 106 clearance.

- Because much of the park is visible to the public, aesthetics after management must be considered. Large, dense and highly visible infested areas may require restoration after management (removal of dead shrubs and trees, revegetation, visual screening, etc.).

- In order to avoid erosion, management of invasives found on any type of slope must include revegetation of the area.

- Management of invasives found on park boundaries may require coordination with neighboring landowners.

References

Clark, K.H. and C.D. Rafkind. 1998. Conservation Planning for the Natural Areas for Colonial National Historic Park, Virginia. Natural Heritage Technical Report 98-14. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, Virginia.

Heibert, Ronald D. and James Stubbendieck (1993) Handbook for Ranking Exotic Plants for Management and Control. Natural Resources Report NPS/ NRMWRO/ NRR-93/ 08. United States Department of the Interior, National Park Service, Midwest Regional Office.

Ludwig, J. Christopher, Kurt A. Buhlmann and Christopher A. Pague (1993) A Natural Heritage Inventory of Mid-Atlantic Region National Parks in Virginia: Colonial National Historical Park. Natural Heritage Technical Report #93-6. Division of Natural Heritage, 217 Governor Street, 3rd floor, Richmond, Virginia 23219.

Watts, B.D. (2000) Management of Park Fields to Enhance the Natural Resource Value and Biodiversity of Colonial National Historical Park. Center for Conservation Biology, The College of William and Mary, Williamsburg, Virginia 23187.

Appendix 1: Lessons Learned

- During the first year of this survey, Yorktown forested areas ware initially surveyed, and infested areas were mapped. Once this stage was complete in a small area of forest, each infested area was revisited to collect 3-6 measurements of coverage for each exotic and native species. Measurements for canopy cover were taken, and the number of stems was counted for each exotic tree, shrub, or vine. While this resulted in useful information, a great deal of time was used in finding the infested areas a second time. Because estimated coverage values can provide information that is nearly as useful and will allow the researcher to complete more of the park in less time, the protocol will be altered to eliminate the re-visitation of infested areas for measurements.

- Intensely managed areas, such as roadsides and mowed fields, are often highly infested with a variety of exotics. As a result, attempting to map exotic populations in these areas can be extremely time consuming. In addition, because these areas are often of less natural value than less managed areas, it may not be as important to collect a detailed species distribution. Although the initial inventory protocol required the mapping of exotic populations in all areas of the park, the majority of the park's roadsides, fields, and trails are infested by at least one exotic species. The protocol was altered due to limited time and personnel. Instead of mapping exotic populations on roadsides, fields and trails, these areas will be randomly divided into equally sized strips inside which the presence or absence of each exotic species will be recorded. This will provide general information such as which species are present in each area, and approximately how much of each species there is.

- During the first field season of this inventory, it was found that the majority of infested areas in the park were infested by multiple species of invasive exotics. Mapping individual species populations, in this case, would require a great deal of time mapping the same area repeatedly. Mapping infested areas as a whole, while keeping record of the species present and their estimated coverage in each area, can provide a clear representation of invasive species distribution within the park while requiring a great deal less time mapping individual species populations.

- The original inventory protocol required the use of the GPS unit for the mapping of all infested areas. However, it was found that recording the location of an area using GPS technology can be extremely time consuming, and, in many cases, unnecessary. If it is possible to determine the location of the area by using landmarks, such as roads, streams, fields, etc., mapping infested areas by hand can provide an accurate representation of infested locations while requiring a great deal less time.

Appendix 2: Protocol for Inventory of Invasive Exotic Flora

Objectives:

- To determine the species, distribution and abundance of invasive exotic plant species (hereafter "invasives") throughout Colonial NHP.

- To create a GIS map of distribution of invasives within the park.

- To estimate the cost and effort involved in invasive species control, taking into consideration the predicted response of the native community to management.

- To use inventory data to prepare an invasive species mitigation plan.

Step 1: List of Invasives

A list of invasives known to exist in York, James City, and immediately surrounding counties was created using data compiled by the Division of Natural Heritage**,** and the Virginia Native Plant Society, along with several other sources (Harvill *et al*., 1992; Havens, Personal Communication; Swearingin, Personal Communication) (see Appendix A).

Step 2: Locating Invasives

In order to obtain an accurate assessment of the presence and distribution of invasives within the park, it is necessary to sample evenly throughout. However, setting up sample plots randomly throughout the park, in addition to mapping the perimeters of infested areas, would require more time and personnel than are available. Walking areas of the park along evenly distributed transects may provide a more direct method of inventory, by allowing the surveyor to simultaneously create a field map of species distribution as well as record the necessary information about each infested area.

Due to the difference in layout and mode of access for each ecotype within the park, the most effective way to inventory was determined to be different for each.

Forests (including forested wetlands) and Fields - These habitats within the Yorktown, Jamestown Island, and Green Spring units of the park will be divided into sections using landmarks such as roads, park borders and obvious ecotones (such as field and forest borders) as boundaries. Within each section, the surveyor will walk a series of transects, 40 meters apart, until the section has been covered. While walking, the surveyor will look for invasives throughout his or her entire field of vision, approximately 10 meters in all directions. **Note:** In order to inventory only the intended section, the surveyor should place the first transect approximately 20 meters from the section boundary.

Non-Forested Wetlands - Due to the difficulty of accessing these habitats, they will be viewed from several vantage points along the shoreline and by boat where necessary. Areas of invasives will mapped referencing landmarks and aerial photography

Colonial Parkway- The width between the edge of parkway and park boundary on either side (approximately 72 meters) will divided into 20 m strips. The surveyor will walk a single transect perpendicular to the parkway through the middle of each strip. Invasives will be inventoried within 10 meters on either side of the transect. In this way, each transect will form the midline of a 20 x 72 meter strip inside which invasives will be inventoried.

Roads and Trails (other than Colonial Parkway) -The 10 meter width adjacent to each edge of all roads and trails within the Yorktown, Jamestown and Green Spring units will be divided into 100 meter strips. These 10 x 100 meter strips will be surveyed for invasives from the road or trail.

Due to their unique value to the park as well as the state, the following areas have been identified as Natural Areas (Clark *et al*., 1998) and will be prioritized for inventory.

- Areas serving as habitat for rare, threatened, or endangered plants or animals.
- Areas containing rare or state significant natural communities.
- Areas containing significant geological landmarks.

Step 3: Mapping Invasive Species

As invasive species populations are located within the park (as described above), their perimeters will be mapped. The resulting data will be incorporated into the Park Geographical Information System (GIS), as a series of polygons, each one representing a separate mapped area (polygon). Perimeter mapping will provide an accurate description of the general distribution pattern of invasives throughout the park. Further, it will provide an estimate of time, effort and equipment required for control. **Note:** It was found that the two species, *Microstegium viminium* and *Lonicera japonica,* were present throughout the majority of the park. This eliminated the possibility of thoroughly mapping these species' distributions within the time allotted for the inventory.

In order to accurately (within $1m^2$) define the location and areal coverage of plant populations, it is ideal to map populations using a Global Positioning System (GPS) unit. However, if a population's location can be referenced by permanent landmarks (i.e. roads, trails, marked boundaries, perennial streams, obvious changes in topography, etc.), it can be hand-drawn on a 1:2400 scale map with similar accuracy (+/- 5 ft), and less time.[1] Therefore, invasive populations in forests (including forested wetlands) and fields will be mapped via GPS only if it is impossible to determine their locations manually. Hand mapped areas can then be incorporated into the GIS via screen digitizing. Invasive populations in non-forested wetlands will be hand mapped from the shoreline or boat and digitized into the GIS database. Invasives found adjacent to roads (including the Colonial Parkway) and trails will be digitized into the GIS in the form of strips inside which the invasive species will be identified.

Because many exotic populations within the park have been found to overlap, it would be extremely time consuming to map each population separately. Thus, the mapping process will reflect the general pattern of infestation in each area by using a combination of the following categories:

Mapped areas will be defined using the following categories representing the number of invasive species:

- Area is infested by a single exotic species
- Area is infested by 2-3 exotic species
- Area is infested by 4-5 exotic species
- Area is infested by greater than 5 exotic species

Mapped areas will also be defined using the following categories representing the total cover of all invasive vegetation:

- Percent cover of exotic vegetation is less than 25%

[1] COLO GIS database is registered to 1:2400 and digital photography to +/- 5ft accuracy.

- Percent cover of exotic vegetation is between 25 and 50%
- Percent cover of exotic vegetation is between 51 and 75%
- Percent cover of exotic vegetation is greater than 75%

So that mapped areas can be identified with a specific location of the park, each area will be labeled with an appropriate Location Code. The Location Code will based on the division of Yorktown, Jamestown Island and the will be divided into arbitrarily numbered sections. Location section boundaries will defined by permanent landmarks (such as roads) where possible and will otherwise be arbitrary divisions. The Colonial Parkway corridor will be divided at kilometer markers to form location sections. Each Location Code will consist of two letters representing the unit of the park (Yt, Jt, or CP), and one or two digits representing the section of each unit in which the mapped area is found (e.g. CP1, CP2, etc). Location Codes for Yorktown and Jamestown Island are represented in Figure 1. Green Spring will be considered a single section with the Location Code, 'GS'.

Each mapped area will be identified by a Polygon Code. This will consist of the following: a) The polygon's Location Code; b) The six digit species code (first three letters of the genus + the first three letters of the species) which identifies the most abundant exotic species; c) one letter representing the infestation level (a= >75% exotic cover, b= 25-75%, c= <25%); d) 1-2 digits distinguishing the polygon from those with otherwise identical codes (Example: Yt2.Ligsin.a.1, Yt2.Ligsin.a.2, etc.).

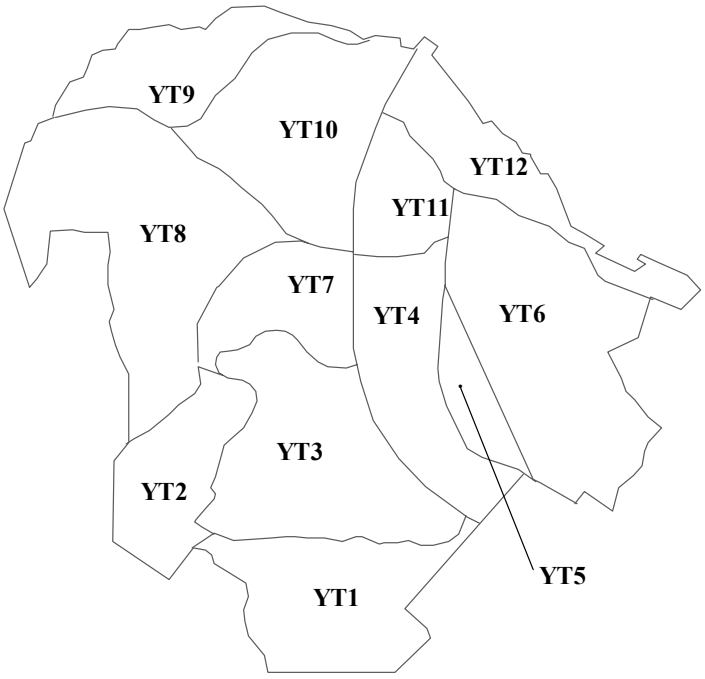
Additional information collected in each mapped area is listed in Table 1. If the area is mapped via GPS, the information can be entered into the GPS Data Dictionary and downloaded into the GIS database. If the area is hand mapped and/or digitized into the GIS database, the surveyor will fill out a mapping data form (See Appendix B) and enter data manually into the database.

Step 4: Calculations

Parkwide Area of Infestation - Using the polygons created in the 'Mapping Invasives' step of the protocol, it will be possible to determine the approximate acreage inhabited by each invasive species (by totaling the acreage of all polygons in which a species is found). Further, by using the estimated percent cover for each invasive species in each mapped polygon, it will be possible to divide the above acreage into percent cover ranges. **Note:** Because *Microstegium viminium* and *Lonicera japonica* were not mapped completely, the area of infestation for these species cannot be determined. However, from qualitative observation, it can be said that both species are present throughout the majority of the park.

> **Forests and Fields-**As described in 'Step 2: Locating Invasives', due to the 40-meter width of the walked transects, and the approximate length of the surveyor's vision (10 meters on either side), he/she will see approximately 50% of the forests and fields inventoried. Therefore, by doubling the coverage of mapped invasive populations and/or communities, the surveyor is able to get an estimate of the actual areal coverage of these populations or communities.
>
> **Roadsides-**Roadside and Parkway data can also be described in the form of a frequency. For example, it will be possible to determine what percentage of the parkway transects or roadside strips (See 'Step 2: Locating Invasives') contain each invasive species.

a.



b.

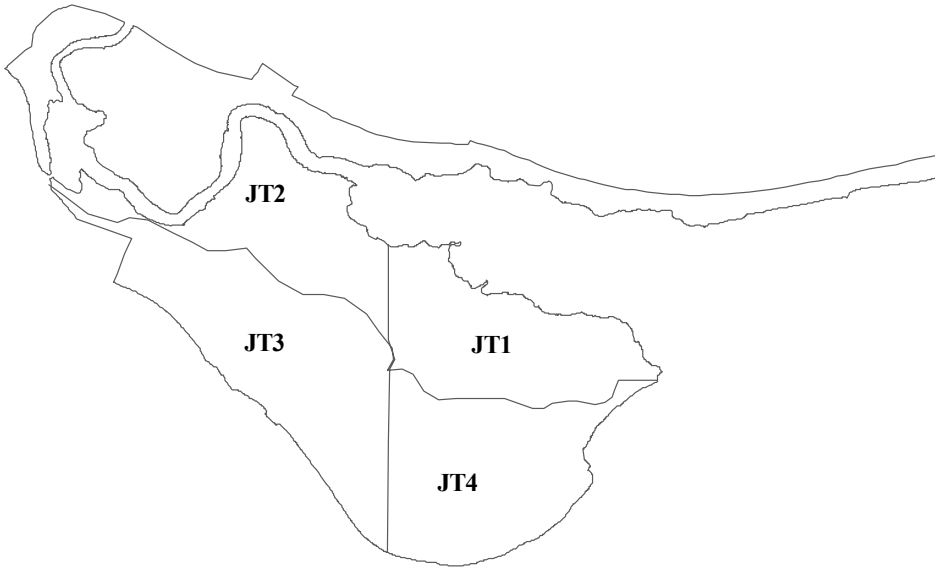


Figure 1. The Location Codes used to identify sections of Yorktown (a) and Jamestown Island (b).

Table 1. The information attributes collected within each mapped area; corresponds with data form in Appendix A.

Attribute	Description
Mapper	Enter the first and last initial of the person who mapped the polygon (multiple names should be divided with a forward slash)
Mapping Date	Enter the date on which the polygon was mapped (DD/MM/YYYY)
Polygon_Code	Enter the code assigned to the polygon being entered
Strip Number	For roads and trails only. Enter a 5-digit number for the strip starting at 0 and increasing sequentially according to the number of kilometers the beginning of the strip is distanced from the starting point. Last digit of the number is L or R indicating if the strip is located in the left or right side of the road. Example: 0.000L
Invasive Species	Choose the appropriate number range of invasive exotic species found in the polygon: 1, 2-3, 4-5, >5 species
Invasive Cover	Choose the appropriate estimated range of total percent cover of all invasive exotics contained in the polygon: <25%, 25-50%, 51-75%, >75%
Species	Enter the 6-digit code each invasive species in the polygon (first three letters of genus name + first three letters of the species name).
Cover[1]	For each invasive species contained in the polygon, estimate the percent of the ground area covered by vegetation below 2 meters height (% Cover Ranges: <5, 5-10, 11-25, 26-50, 51-75, >75).
Stems[1]	For each invasive shrub and vine species entered above, estimate the number of stems/100 meters^2 above 2 meters height (use above ranges).
Estimated Trees[1] (DBH Class 1)	For each invasive tree species contained in the polygon, estimate the number of stems/100 meters^2 which are >2 meters in height and have a DBH of <5 cm. (Number of Stems: <5, 5-10, 11-25, 26-50, 51-75, >75).
Estimated Trees[1] (DBH Class 2)	For each invasive tree species contained in the polygon, estimate the number of stems/100 meters$^{2,\ which}$ are >2 meters in height and have a DBH of 5-10 cm. (Number of Stems: <5, 5-10, 11-25, 26-50, 51-75, >75).
Estimated Trees[1] (DBH Class 3)	For each invasive tree species contained in the polygon, estimate the number of stems/100 meters$^{2,\ which}$ are >2 meters in height and have a DBH of 11-20 cm. (Number of Stems: <5, 5-10, 11-25, 26-50, 51-75, >75).
Estimated Trees[1] (DBH Class 4)	For each invasive tree species contained in the polygon, estimate the number of stems/100 meters^2 which are >2 meters in height and have a DBH of >20 cm. (Number of Stems: <5, 5-10, 11-25, 26-50, 51-75, >75).
Boundary[2]	Is the polygon on or within three meters of a park boundary? (Y/N)
Special Status[2]	Choose the appropriate status of the polygon: Natural Heritage Area, Natural Heritage Area Buffer, Conservation Zone, Cultural Resource, Cultural Landscape, No Status
Location	Choose the appropriate location of the polygon: Roadside, Trailside, Other
Disturbance	Choose any disturbance which may have occurred in the area of the polygon: Weather damage, Insect damage, Fire, Flooding, Old homesite, Old roadbed
Management Issues[2]	Choose any management issue associated with the area of the polygon: Proximity to water, Neighbor issue, Cultural resource damage, Visibility of area, Erosion potential
Habitat[2]	Choose the appropriate habitat of the polygon: Upland Forest, Streamside Forest, Field, Forested wetland, Non-forested wetland
Area (meters^2)	Enter the area in meters of the polygon (determined in GIS)
Location Code[2]	Enter the location code in which the polygon is found (first 2–3 digits of the Polygon Code)

[1]Each potential invasive species will be entered as a column heading under which these estimates will be entered.
[2]This information is best determined by overlaying mapped areas with park data such as park boundaries, Natural Heritage Areas, cultural resources, hydrology and topography.

Appendix A: The data form used for hand-mapping in the field.

Mapper:_____ **Mapping Date:**_____

Road/Trail Name/Field Number:_____

Strip Number: (Roads/Trails only)	**Polygon Code:**	**Invasive Species:** 1 2-3 4-5 >5	**Invasive Cover:** <25% 25-50% 51-75% >75%

Species	**Cover**	**# Stems**	**DBH Class 1**	**DBH Class 2**	**DBH Class 3**	**DBH Class 4**	**Location**	**Disturbance**	**Management Issues**
							Roadside Trailside Other	Weather Damage Insect Damage Fire Flooding Old roadbed Old homesite	Proximity to Water Neighbor Issue Erosion Potential Cultural Resource Damage
							Special Status		**Habitat**
							Natural Heritage Area Natural Heritage Area Buffer Conservation Zone Cultural Resource Cultural Landscape		Upland Forest Streamside Forest Field Forested Wetland Non-Forested Wetland
							Boundary: Yes / No		

Strip Number: (Roads/Trails only)	**Polygon Code:**	**Invasive Species:** 1 2-3 4-5 >5	**Invasive Cover:** <25% 25-50% 51-75% >75%

Species	**Cover**	**# Stems**	**DBH Class 1**	**DBH Class 2**	**DBH Class 3**	**DBH Class 4**	**Location**	**Disturbance**	**Management Issues**
							Roadside Trailside Other	Weather Damage Insect Damage Fire Flooding Old roadbed Old homesite	Proximity to Water Neighbor Issue Erosion Potential Cultural Resource Damage
							Special Status		**Habitat**
							Natural Heritage Area Natural Heritage Area Buffer Conservation Zone Cultural Resource Cultural Landscape		Upland Forest Streamside Forest Field Forested Wetland Non-Forested Wetland
							Boundary: Yes / No		

Strip Number: (Roads/Trails only)	**Polygon Code:**	**Invasive Species:** 1 2-3 4-5 >5	**Invasive Cover:** <25% 25-50% 51-75% >75%

Species	**Cover**	**# Stems**	**DBH Class 1**	**DBH Class 2**	**DBH Class 3**	**DBH Class 4**	**Location**	**Disturbance**	**Management Issues**
							Roadside Trailside Other	Weather Damage Insect Damage Fire Flooding Old roadbed Old homesite	Proximity to Water Neighbor Issue Erosion Potential Cultural Resource Damage
							Special Status		**Habitat**
							Natural Heritage Area Natural Heritage Area Buffer Conservation Zone Cultural Resource Cultural Landscape		Upland Forest Streamside Forest Field Forested Wetland Non-Forested Wetland

Appendix B: Potential Invasives of Colonial NHP[2]

Growth Form	Scientific Name	Common Name	Season of Inventory[3]
Grasses	Agropyron repans	quack grass	early/late summer
	Agrostis gigantea	redtop	late summer
	Arrhenatherum elatius	oatgrass	early summer
	Arthraxon hispidus	jointed grass	fall
	Cynodon dactylon	Bermuda grass	early summer
	Dactylis glomerata	orchard grass	early summer
	Festuca elatior	tall fescue	early summer
	Holcus lanatus	velvet grass	early summer
	Imperata cylindrica	cogon grass	
	Microstegium vimineum	Microstegium	fall
	Phleum pratense	Timothy	late summer
	Phragmites australis	Common reed	fall
	Phyllostachys aurea	golden bamboo	winter
	Poa compressa	Canada bluegrass	early summer
	Poa trivialis	rough bluegrass	spring
	Setaria faberi	giant foxtail	late summer
	Sorghum halapense	Johnson-grass	summer
Herbs	*Ajuga reptans*	bugleweed	spring
	Allium vinale	wild onion	early/late summer
	Alternanthera philoxeroides	alligator weed	spring/early summer
	Artemisia vulgaris	mugwort	late summer/fall
	Carduus nutans	musk thistle	early summer
	Cassia obtusifolia	sickle pod	late summer
	Centaurea maculosa	spotted knapweed	late summer
	Cirsium arvense	Canada thistle	late summer
	Cirsium vulgare	bull-thistle	late summer
	Commelina communis	common dayflower	late summer
	Conium maculatum	poison hemlock	early summer
	Convovulus arvensis	field bindweed	late summer
	Coronilla varia	Crown vetch	late summer
	Egeria densa	Brazilian water weed	early summer
	Foeniculum vulgare	fennel	late summer
	Glechoma hederacea	gill-over-the-ground	spring
	Ipomoea coccinea	Red morning glory	fall
	Ipomoea hederacea	ivy leaved morning glory	late summer
	Ipomoea purpurea	common morning-glory	late summer
	Iris pseudacorus	yellow flag	early summer
	Lespedeza bicolor	shrubby bushclover	late summer
	Lotus corniculatus	birdsfoot trefoil	early/late summer
	Lysimachia nummularia	moneywort	early summer
	Lythrum salicaria	purple loosestrife	late summer

[2] This list has been extracted from "Invasive Alien Plant Species in Virginia", a publication developed, in partnership, by the Virginia Native Plant Society, and the Department of Conservation and Recreation, Division of Natural Heritage. It was then modified with the use of "Atlas of Virginia Flora III," and the knowledge of several listed reviewers.

[3] This provides the season during which the species is most conspicuous (i.e. Flowering or producing fruit).

Growth Form	Scientific Name	Common Name	Season of Inventory[3]
	Melilotus alba	white sweet clover	spring
	Melilotus officinalis	yellow sweet clover	spring
	Murdannia keisak	aneilima	
	Myriophyllum aquatica	parrot's feather	
	Pastinaca sativa	wild parsnip	early summer
	Perilla frutescens	beefsteak plant	fall
	Polygonum cespitosum	bristled knotweed	early summer
	Polygonum cuspidatum	Japanese knotweed	early summer
	Raphanus raphanistrum	jointed charlock	spring
	Rumex acetosella	red sorrel	spring
	Stellaria media	common chickweed	winter
	Trapa natans	water chestnut	early summer
	Xanthium strumarium	common cocklebur	late summer
Shrubs	*Berberis thumbergii*	Japanese barberry	spring
	Elaeagnus pungens	thorny elaeagnus	winter
	Elaeagnus umbellata	autumn olive	spring/late summer
	Euonymus fortunei	wintercreeper	
	Ligustrum obtusifolium	blunt-leaved privet	winter
	Ligustrum sinense	Chinese privet	early summer
	Lonicera x bella	Bell's honeysuckle	spring
	Rosa multiflora	multiflora rose	early summer
	Rubus phoenicolasius	wineberry	early summer
Trees	*Acer platanoides*	Norway maple	spring
	Ailanthus altissima	tree of heaven	sumer
	Albizzia julibrissin	mimosa	early summer
	Melia azederach	China-berry	spring
	Morus alba	white mulberry	spring
	Paulownia tomentosa	empress tree	spring
	Pinus thumbergii	black pine	
	Populus alba	white poplar	winter/spring
Vines	*Cardiospermum halicacabum*	balloon vine	late summer
	Celastrus orbiculatus	oriental bittersweet	spring/late summer
	Dioscorea batatas	Chinese yam	summer
	Hedera helix	English ivy	winter
	Lonicera japonica	Japanese honeysuckle	winter
	Pueraria lobata	Kudzu	late summer
	Vinca minor	periwinkle	spring
	Wisteria floribunda	Japanese wisteria	spring
	Wisteria sinensis	Chinese wisteria	spring/early summer

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Appendix 3: Description of Invasive Species Database

Database Layout

Data collected through the Invasive Species Inventory is stored electronically in two formats: Access databases (Invasives.mdb and Invasives_plot data.mdb) and GIS (Arc View Invasives00.dbf and .shp files). The following description explains what type of data is contained in each file, how these databases are linked, and how useful data summaries can be obtained. This description also serves as a guideline for continuing data entry.

GIS

The Arc View GIS database contains the following fields:

Field Name	Description
Mapper	Identifies the person who did the mapping (first and last initials)
Mapping Date	Identifies the date on which the polygon was mapped (YYYY/MM/DD)
Polygon_Co	Unique code identifying the Polygon
Location	Two or three digit code corresponding to the location of the polygon (e.g.,Yt1)
Strip_numb	The strip number of roadside and trailside polygons as defined in Inventory Protocol. Blank field for records that are not roadside or trailside polygons.
Field_no	The field number for all field polygons; blank for other records.
Area	Provides the area of the polygon in meters and acres (calculated by Arc View)
Perimeter	Provides the perimeter of each polygon in meters. (calculated by Arc View)
Cover_extcs	Places the polygon in a range of percent cover of invasive exotics. (<25, 25-50, 51-75, 75)
No_extcs	Places the polygon in a range of number of invasive species present: (1, 2-3, 4-5, >5)
Species1-Species13	Thirteen fields in which the common names of each species found in the polygon are entered. For polygons with fewer than13 invasive species, the remaining fields remain blank.
S_type	One-word reference to the method of data collection (roadside, trailside, field, wetland, aerial digitized, landmarks, aerial photography, GPS)
Feature	"Monitoring" for all records
Feature1	"Invasive vegetation" for all records

Infested areas (polygons) can be entered into GIS by either 1) directly downloading them from a GPS unit used to record their location, or 2) hand digitized on a table or on-screen from aerial photography or landmark references. For each polygon entered, a corresponding record is created in the GIS database (Invasives00.dbf). Data for these records is either downloaded to the GIS from a data dictionary in the GPS unit, or is manually entered into the listed fields from hard-copy forms used in the field (See Inventory Protocol). Arc View automatically calculates and displays area and perimeter data. More detailed information about each polygon can be found in the Access records with corresponding Polygon Codes.

Queries can be performed to select all polygons containing a particular species of interest (perhaps to locate areas for treatment). For such a query, it is important that all 13 species fields be queried. Queries can also be performed to select polygons based on their relationship to data in other GIS databases or shapefiles. For example, a query can be performed to select all polygons in forested areas.

Access Databases

Two access databases exist; the first contains data gathered in the first field season for random plots (see Inventory protocol), while the second contains data about all other infested areas of the park.

Plot Data:

This database (Invasives_Plot data.mdb) consists of several linked tables containing data collected at a series of plots placed randomly throughout the park's forested habitat. Because *Microstegium viminium* and *Lonicera japonica* (Japanese honeysuckle) were so abundant throughout the park, plots were set up to determine the parkwide coverage of these two species rather than mapping each population (See Inventory Protocol for plot setup). The information contained in each table is as follows (Arrows represent links between tables):

Polygon Information:

Field Name	Description
Mapper	Identifies those completing the plot
Mapping Date	Identifies the date on which the plot was completed
Polygon_Code	Identifies the plot (links this table to 'Transect Information')
Habitat	Identifies the habitat type of the plot (Field, Forest, Riparian wetland)
Disturbance1-Distrbance2	Identify disturbances to vegetation in the plot area (Weather damage, Insect damage, Mowing, Deer browse, Old roadbed, Old homesite, Fire)
Management Issues 1-2	Identifies considerations for management of invasives in the plot area (Visibility, Neighbor issue, Proximity to water, Erosion potential, Cultural resource damage)
Area (meters, hectares, acres)	The area of the plot, as determined in GIS
Species1-Species5	Contain the 6-letter code for each invasive species found in the plot

Transect Information:

Field Name	Description
Polygon_Code	Identifies the plot (Links this table to 'Polygon Information')
Trans_No	Identifies the transect along which data is being collected (Links this table to remaining three tables)
T_Length	Gives the length of the transect (meters).
Trans_Drct	Gives the direction in which the transect extends from the center of the plot (degrees).
Exotic Cover	The total length of the transect intersecting with invasive spp. foliage
Native Cover	The total length of the transect intersecting native spp. foliage
Cover (Herbs, Grasses, Shrubs, Trees, Vines)	The length of the transect intersecting foliage of native herbs, grasses, shrubs, trees and vines

Random Plot Species (below 2m):

Field Name	Description
Trans_No	Identifies the transect along which data is being collected (Links this table to 'Transect Information')

Exotic Cover	Percent ground cover (percent of transect length intersecting with any exotic species under 2m in height.
Species (Ailalt, Ligsin, Lonjap, Micvim, Rosmul, Stemed, and Vinmin)	Percent ground cover by each invasive species below 2m will be recorded. Field names are the six letter code for each invasive species found.

Random Plot Shrubs and Vines (above 2m):

Field Name	Description
Trans_No	Identifies the transect along which data is being collected (Links this table to 'Transect Information')
Exotic Stems	The number of stems of exotic shrubs and vines >2meters found in subplot
Species (Ligsin, Lonjap)	The number of stems of each exotic species found in the subplot, listed in a field named by the 6-letter code for the species.

Random Plot Trees (above 2m):

Field Name	Description
Trans_No	Identifies the transect along which data is being collected (Links this table to 'Transect Information')
Exotic stems	The total number of stems of exotic trees >2meters found in the sub-plot
Ailalt_1 – Ailalt_4	The number of Ailanthus altissima stems of >2merters height and <5cm, 6-10cm, 11-20cm, and >20cm DBH, respectively. (Note: Ailalt was the only invasive tree found in plots)

Parkwide Data:

This database (Invasives.mdb) contains information about all non-plot polygons throughout the park and about all invasive species found within the park. Like the previous database, it consists of several linked tables. Tables are described below (All tables are linked by Polygon Code):

Locations*

Field Name	Description
Mapping Date	Identifies the date on which the polygon was mapped (DD/MM/YYYY)
Polygon_Code	Identifies the Polygon being entered
Location	Identifies the general location of the polygon (Field, Forest, Roadside, Trailside, Wetland)
Road Name	Name of road for roadside polygons, empty field where not appropriate.
Strip Number	For roads and trails only. Enter a 5 digit number for the strip starting at 0 and increasing sequentially according to the number of kilometers the beginning of the strip is distanced from the starting point. Last digit of the number is L or R indicating if the strip is located in the left or right side of the road. Example: 0.000L
Field Number	Field number for field polygons, empty field where not appropriate.

*Data in this table is entered directly into Access via the Data form.

Ground cover (below 2 meters)*

Field Name	Description
Polygon_Code	Identifies the Polygon being entered
Species (Ailalt, Arthis, etc.)	One field for each invasive species in the park; named for the species 6-letter code. Data entered into each field indicates the percent ground cover of that species in the polygon (0, <25, 25-50, 51-75, >75)

*Data in this table is entered directly into Access via the Data form.

Stems (shrubs and vines)*

Field Name	Description
Polygon_Code	Identifies the Polygon being entered
Species (Berthu, Celorb, etc.)	One field for each invasive species in the park; named for the species 6-letter code. Data entered into each field indicates the number of stems >2 meters high per 10 meters squared of that species in the polygon (0, <1, 2-4, 5-10, 11-25, 26-50, >50))

*Data in this table is entered directly into Access via the Data form.

Polygon Stems (trees)*

Field Name	Description
Polygon_Code	Identifies the Polygon being entered
Species_1 (Ailalt_1, Albjul_1, etc.)	One field for each invasive tree in the park; named for the species 6-letter code. Data entered into each field indicates the number of stems >2 meters high and <5cm DBH per 10 meters squared of that species in the polygon (0, <1, 2-4, 5-10, 11-25, 26-50, >50))
Species_2 (Ailalt_2, Albjul_2, etc.)	One field for each invasive tree in the park; named for the species 6-letter code. Data entered into each field indicates the number of stems >2 meters high and 5-10cm DBH per 10 meters squared of that species in the polygon (0, <1, 2-4, 5-10, 11-25, 26-50, >50))
Species_3 (Ailalt_3, Albjul_3, etc.)	One field for each invasive tree in the park; named for the species 6-letter code. Data entered into each field indicates the number of stems >2 meters high and 11-20cm DBH per 10 meters squared of that species in the polygon (0, <1, 2-4, 5-10, 11-25, 26-50, >50))
Species_4 (Ailalt_4, Albjul_4, etc.)	One field for each invasive tree in the park; named for the species 6-letter code. Data entered into each field indicates the number of stems >2 meters high and >20cm DBH per 10 meters squared of that species in the polygon (0, <1, 2-4, 5-10, 11-25, 26-50, >50))

*Data in this table is entered directly into Access via the Data form.

Disturbance*

Field Name	Description
Polygon_Code	Identifies the Polygon being entered
Disturbance 1	Lists any disturbance that has occurred in the area of the polygon (Weather damage, Insect damage, Flooding, Fire, Old roadbed, Old homesite)
Disturbance 2	Lists any disturbance (not listed above) that has occurred in the area of the polygon (Weather damage, Insect damage, Flooding, Fire, Old roadbed, Old homesite)
Disturbance 3	Lists any disturbance (not listed above) that has occurred in the area of the polygon (Weather damage, Insect damage, Flooding, Fire, Old roadbed, Old homesite)

*Data in this table is directly into Access via the Data form.

Management Issues*

Field Name	Description
Polygon_Code	Identifies the Polygon being entered
Visibility	"Yes" if polygon is adjacent to road, trail, or field where visible to visitors; otherwise "No"
Proximity to Water	"Yes" if polygon is within 20 meters of a stream, pond, river, or wetland; otherwise "No"
Cultural Issue	"Yes" if polygon is within 5 meters of any cultural resource or is part of a cultural landscape; otherwise "No"
Erosion Potential	"Yes" if polygon is located on a slope; otherwise "No"
Neighbor issue	"Yes" if polygon is within 3 meters of a park boundary; otherwise "No"

* Data in this table can be entered directly into Access. Alternatively, values for all fields can be calculated through queries in GIS and imported into Access.

The parkwide Access database also contains a query listing the acres covered by each species in each polygon. This query is in turn used in two reports: 1) Acres and Number of polygons per Species per Habitat type(Field, Forest, etc.), and 2) Acres and Number of Polygons per Species per Location (Roadside, Trailside, etc.). These reports summarize the total number of acres of each invasive species in the park.